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CALIFORNIA COAST NEARSHORE PROCESSES STUDY

ERTS-A EXPERIMENT #088

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September 1973

Type II Progress Report for Period March 1, 1973 to August 31, 1973

Prepared for:

Goddard Space Flight Center
Greenbelt, Maryland 20771

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16. ABSTRACT

This Type II progress report for March-August 1973 contains the analysis of California coastal currents from three ocean seasons (Davidson Current, Upwelling and Transition). ERTS imagery for each season was assembled into a mosaic of the California coast. The imagery was processed for interpretation utilizing Flying Spot Scanner enhancements, computer contouring of scene radiance levels and microdensitometer plots. Tentative calibration of ERTS spectral brightness against sediment load was made using aircraft and shipboard measurements. Distinct seasonal patterns for sediment transport as a function of ocean current systems and coastal morphology were identified. Uses for the ocean dynamic system analysis were identified at numerous sites along the California coast including the Mad River, Monterey Bay, Oxnard Shores and Oceanside. Large scale sediment plumes from intermittent streams and rivers were found to extend offshore to heretofore unanticipated ranges.

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PREFACE

This Type II Progress Report for California Coast Nearshore Processes Study, Contract S-70257-AG, is submitted to the Goddard Space Flight Center for the period March 1 to August 31, 1973. This report was prepared by the U. S. Army Engineering District, San Francisco, and the Earth Resources Programs group of Rockwell International, Downey, California.

The Space Division's Earth Resources Programs group of Rockwell International will be re-identified as the Geoscience Division of Geosource International, which is an affiliate of Rockwell International on October 1, 1973. Therefore, in all subsequent progress reports of this study, the Geoscience Division will appear as the subcontractor to the U. S. Army Corps of Engineers. The Geoscience Division will remain at the same location as the Space Division (Seal Beach Facility), utilizing the same personnel, equipment, facilities, and capabilities as available prior to October 1, 1973.

The objective of this study is to analyze nearshore currents, sediment transport, estuaries, and river discharge along the California coast through the use of synoptic, repetitive imagery from the Earth Resources Technology Satellite (ERTS). During ERTS overpasses, airborne and sea truth data were also collected for comparing and confirming details of nearshore processes that were detected on ERTS imagery. Four test sites along the California coast (San Francisco, Monterey Bay, Santa Barbara Channel, and Los Angeles area) were emphasized during the interpretation of the overall ocean surface dynamic structure. During this six-month period, major effort was placed on four analysis techniques: (1) mosaic analysis of three California coast ocean seasons using visual and densitometer analysis of suspensates to determine surface dynamics; (2) computer contouring investigation of radiance level distribution; (3) investigation of the relationship between ERTS scene radiance levels and suspended sediment content; and (4) use of flying spot scanner enhancements to facilitate detection and interpretation of subtle suspended sediments. The results of this study will be incorporated into the U. S. Army Corps of Engineers operational plans for the California coast.

The major conclusions that are described in detail in this report are as follows: 1) Distinct seasonal patterns for sediment transport as a function of ocean current systems and coastal morphology have been identified. 2) Large scale sediment plumes for intermittent streams and rivers extend offshore to heretofore unanticipated ranges as shown on the ERTS imagery. Areas where these plumes contain possible contamination from on-land activities can be traced in detail. This is true of the Santa Maria River - Anacapa Island area. 3) Computer generated contouring of radiance levels from NASA-CCT, resulted in maps that can be used in determining surface and near-surface suspended sediment distribution 4) Flying Spot Scanner enhancements resulted in details of nearshore features. 5) Data from this study is providing significant information for coastal planning and construction projects (ie, Mad River Beach study).

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1.0 INTRODUCTION AND SUMMARY

The objective of this study is to analyze nearshore currents, sediment transport, estuaries, and river discharge along the California coast through the use of synoptic, repetitive imagery from the Earth Resources Technology Satellite (ERTS). During ERTS overpasses, airborne and sea truth data were also collected for comparing and confirming details of nearshore processes that were detected on ERTS imagery. Four test sites along the California coast (San Francisco, Monterey Bay, Santa Barbara Channel, and Los Angeles area) were emphasized during the interpretation of the overall ocean surface dynamic structure. During this six-month period, major effort was placed on four analysis techniques: (1) mosaic analysis of three California coast ocean seasons using visual and densitometer analysis of suspensates to determine surface dynamics; (2) computer contouring investigation of radiance level distribution; (3) investigation of the relationship between ERTS scene radiance levels and suspended sediment content; and (4) use of flying spot scanner enhancements to facilitate detection and interpretation of subtle suspended sediments. At numerous locations, the nearshore features were also investigated utilizing both aerial photography (high and low altitude) and sea truth data. The aircraft sensor information was supplied by both NASA and Rockwell International Corporation. Sea truth was collected by the principal investigator and co-investigator and supplemented primarily by data from the U. S. Army Corps of Engineers (USACE), the University of Southern California, the Office of Naval Research, the University of California at Santa Cruz, and the National Park Service.

One of the major results of this study to date is the ability to detect the source of movement of sediments in the nearshore and offshore zone. This sediment interpretation capability resulted from analyzing the ERTS-MSS "green band" imagery. Included were individual frames and three mosaics of the California coast which were assembled for specific ocean current seasons. Contrast between clear ocean water and sediment laden water is possible through both visual interpretation of tone contrast and through enhancement techniques. These processes were applied to the transparencies and computer compatible tapes (CCT). Distribution of sediments from riverine discharge and coastal erosion is possible along the coast out to distances of 100 miles and more. A complex interrelationship of energy sources including wind, tide, and current modified by bottom topography and atmospheric conditions governs the movements of coastal waters. These transitory processes acting over an area as large as the California coast presents a complex analysis problem whose solution is significantly aided using ERTS imagery. The ability to detect current direction and horizontal distribution, upwellings, current blockage, offshore movements, gyres, sediment sources, and nearshore and offshore current reversals represents a valuable new contribution to coastal information and USACE operations.

Along the California coast, the dominating factor in nearshore processes dynamics is the California Current which moves generally southeast. In the winter time, the northward-directed nearshore Davidson Current (Section 2.1) moves opposite to the south-moving California Current further offshore. This northward flow in winter (mid-November to mid February) is attributed to the seasonal change in the wind patterns across California, Oregon, and Washington. The winter winds are primarily from the south and southeast in the coastal area. The effect of this opposite coastal current movement is brought out in detail during ERTS imagery analysis. About halfway through February another major change in wind direction annually causes the phenomena of nearshore upwelling to occur resulting in the Upwelling Period (Section 2.2). During this period the prevailing coastal winds are from the northwest and tend to speed up the surface current and maintain the flow parallel to the coast. In some areas immediately adjacent to the coast, the northern component of the winds are often increased. When this occurs, the influence of the westerly component of the wind on the surface layer becomes insufficient to prevent surfacing of the deeper layer cold water that has built up against the coast. The result is an upwelling which brings the colder water to the surface. This effect seems to be intensified south of capes and points which extend out into the California Current stream. Along the California coast, as noted in the ERTS imagery, upwellings were occurring near Cape Mendocino, Point Conception, and Crescent City during March-April 1973. The cooler water associated with the upwelling waters are often rich in nutrients with the result that phytoplankton blooms often occur in this period. The third mosaic presented, is titled the Transition Period (Section 2.3) and includes available imagery from the time period between the Upwelling Period (March-April) and the Oceanic Period, which dominates from mid-July to mid-November.

The detectability of nearshore processes and open ocean current is dependent to a great degree on the amount and distribution of suspensates in the coastal waters. In addition to the use of the common interpretative techniques for coastal processes (i.e., densitometer, additive color, photographic density enhancement), three major methods of analysis have been developed. The first method is the use of suspended sediment samples (Section 2.4) and transmissometer data to calibrate and compare radiance levels found in the ERTS imagery. This analysis was used in conjunction with the CCT contouring described in Section 2.6 in order to analyze sediment distribution in the test areas of interest. The second technique is the use of the flying spot scanner (FSS) to convert tape to film. This technique is used to expand the restricted ERTS signal dynamic range that corresponds to suspensates in coastal waters. It amplifies this signal range prior to recording, so the features of interest are emphasized in the played-back enhancement (see Section 2.5). The third technique is the use of the NASA computer compatible tapes (CCT) in playback enhancements and in the contouring of radiance levels (see Section 2.6). The contours are related to sediment content in the coastal and offshore areas as determined by sea truth collections and data analyses described in Section 2.4. In each case, these techniques have resulted in the enhancement of subtle or non-detectable (by human eye) signal levels in the ERTS data.

Identification of important processes operating in a coastal environment and understanding their relative importance and mutual interactions are prime requirements in

interpreting coastal water dynamics and in designing coastal structures. This study has resulted in details of nearshore processes as well as the dynamic of the three ocean seasons. Investigations of the ocean season currents have been going on for years, but essentially no simultaneous data source as extensive as ERTS has been available. The use of the ERTS information in analyzing future and present coastal construction sites is of primary value to the U.S. Army Corps of Engineers.

Numerous potential sites along the California coast are being considered for coastal protection construction or for dams (rivers discharging into the ocean). Included in these sites are the Pajaro (Monterey Bay), Russian and Mad Rivers, and construction near Carmel, Santa Maria, Oxnard Shores, Oceanside, and Silver Strand. Although each of these sites requires a thorough ground survey, it has become evident that ERTS imagery analysis results in valuable input to the overview of coastal dynamics. The possible effect of a dam on the Mad River is a good example. A study by the U.S. Army Corps of Engineers of the ocean beaches in the vicinity of the Mad River mouth (near Humboldt Bay) is in progress. The purpose of the study is to develop a conceptual model of the coastal processes in the area, and to determine the effects of an upriver dam (Richard Ecker, personal communication). Included in the Mad River analysis was an interpretation of ERTS imagery for seasonal changes in nearshore currents and sediment transport. This superficial interpretation has resulted in some knowledge of details of offshore as well as nearshore surface dynamics. As ERTS coverage continues, it will be possible to build accurate and comprehensive historical records for such sites. In many studies, this type of historical data is not available for use in monitoring existing coastal phenomenon and planning future coastal modifications.

The U.S. Army Corps of Engineers' responsibility includes coastal protection, improvement of coastal engineering knowledge and the study of nearshore coastal processes. At the present time, over 80 percent of the population of California live along the coast; therefore nearshore and offshore data is vital to the USACE's operational districts. Authorities on coastal processes generally agree that understanding of these processes are still in a rudimentary stage. It appears that present information available on ERTS imagery, when utilized by coastal scientists and engineers, will greatly add to solving the specific problems encountered in the coastal zone.

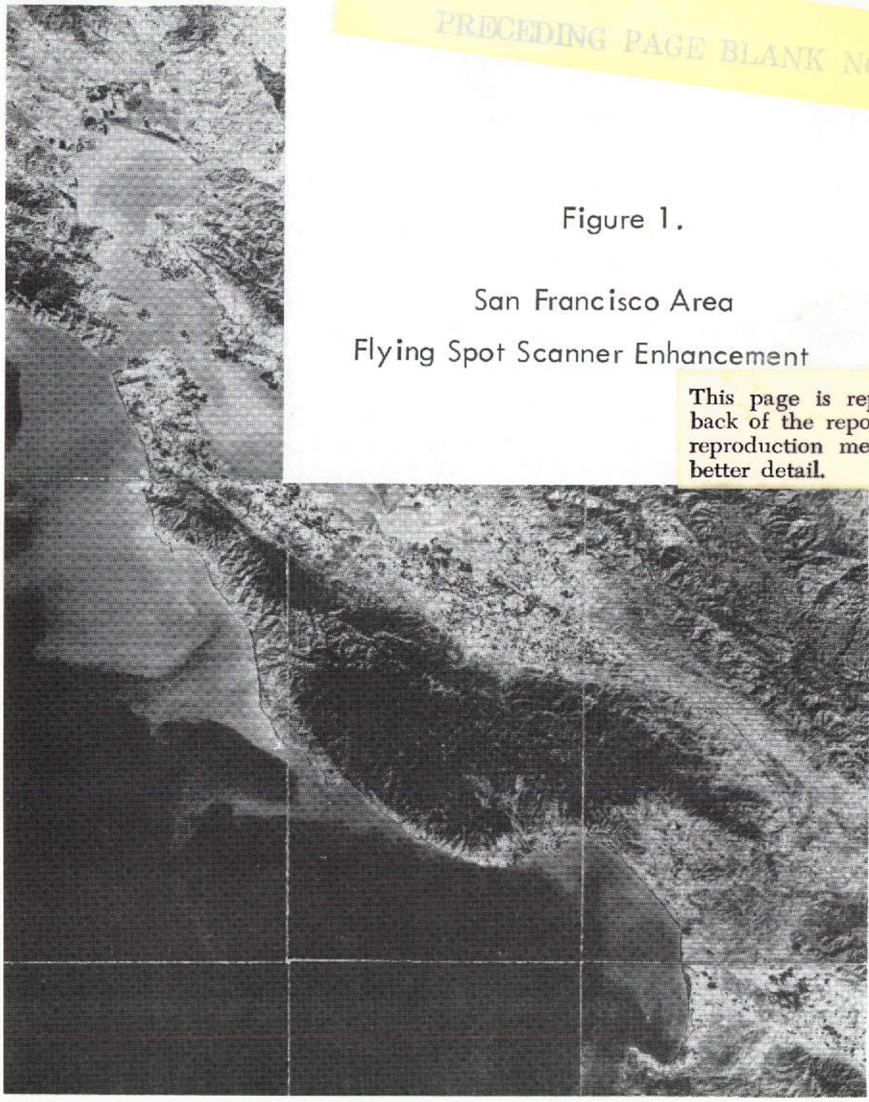


Figure 1.

San Francisco Area

Flying Spot Scanner Enhancement

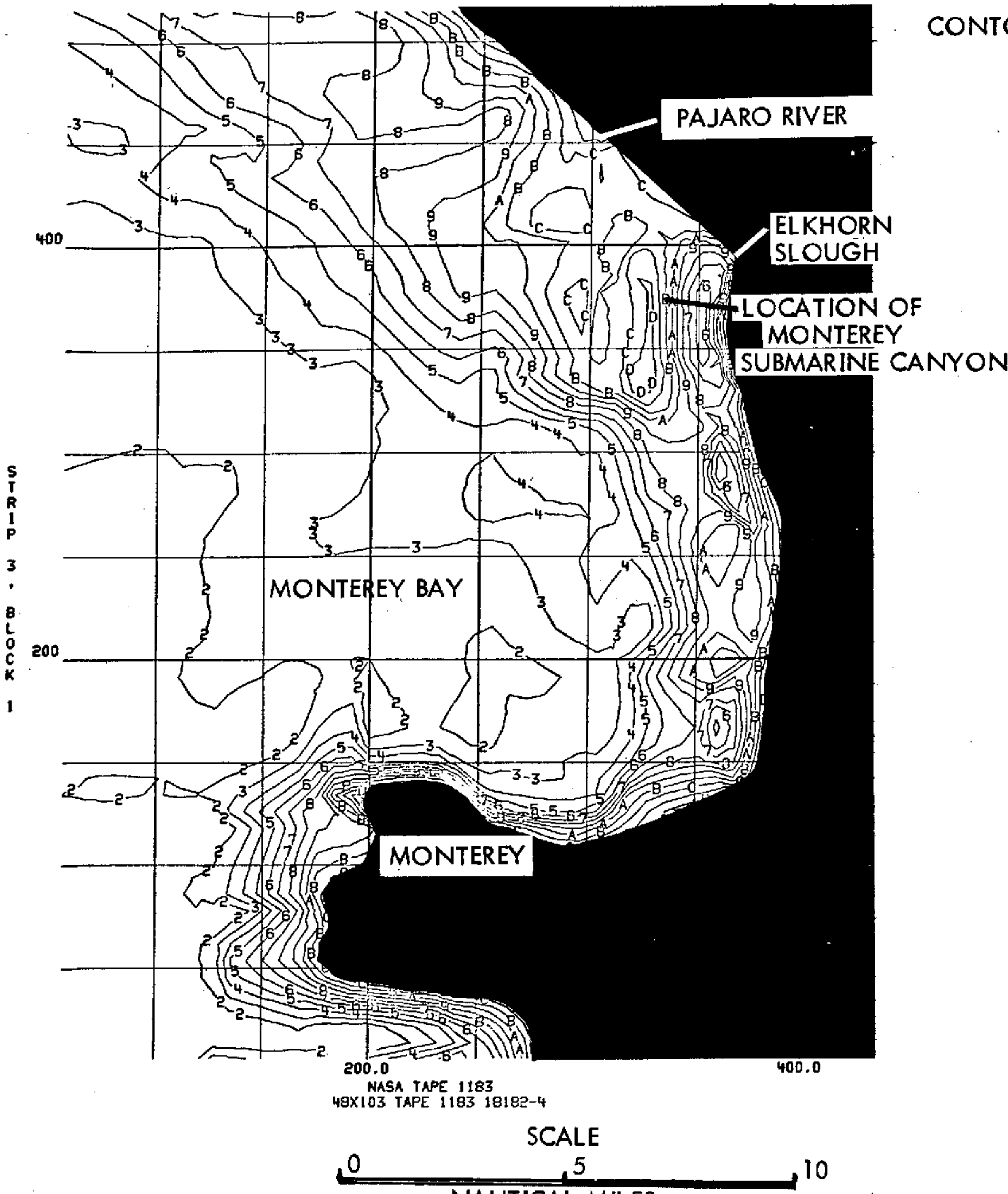
This portion of ERTS scene 1165-18175-4 was enhanced for nearshore suspended sediment detection and delineation. San Francisco is in the left upper section of the scene and Monterey Bay in the lower right. Data from NASA computer compatible tape was converted to hard copy film imagery through a flying spot scanner. Signal gain and DC levels were controlled to achieve optimum contrast in the offshore area. Section 2.6 gives details of this process. This technique along with non-linear amplification, thresholding, and differentiation were utilized as enhancement processes.

This picture was collected on January 4, 1973 at 1017 A.M. Pacific Standard Time. The tidal stage at the Golden Gate Bridge north of the San Francisco peninsula was flooding (high tide 1039 - 6.0 feet). This is the Davidson Current Period of the year when nearshore currents are moving north and northwest. This is opposite to the dominant California Current which operate through the rest of the year. The effects of the Davidson Current are brought out in detail by this contract enhancement. In Monterey Bay sediment is moving northward from the Pajaro River and Elkhorn Slough to the vicinity of Santa Cruz where a counterclockwise gyre is formed. Off Pt. Ano Nuevo an offshore movement of sediment takes place and extends in a curved pattern offshore approximately 25 miles. Large quantities of sediment are present in the nearshore area north to Bolinas Bay. Off the Devils Slide area, several eddys are clearly visible. Layering and gyre activity within the sediment laden waters are clearly emphasized by this enhancement technique. technique.

Figure 2. Monterey Bay Contour Map

The computer processed contour map of Monterey Bay was generated from ERTS bulk CCT scene 1183-18182-4, January 22, 1973. The scene was collected during the Davidson Current period when nearshore surface current movement was generally in a northerly direction. The higher radiance levels, generally represent areas of greater suspended sediment content. The detailed discussion of the relationship of suspended sediment to radiance levels is discussed in Section 2.4. Here it will suffice to say that maximum ERTS radiance is the scene radiance which gives a count of 128. In processing the CCT it was found that the total range representing the nearshore waters is limited to steps 15-25 of the total 128.

In the water adjacent to Elkhorn Slough, radiance counts as high as 24 appear (Contour D). This represents higher reflectance and large amounts of suspended sediment. Open ocean water is represented by radiance counts of 14 and 15 (Contours 2 and 3). Distribution of contours indicate initial offshore movement of suspended sediments from Elkhorn Slough. A northerly directed current (Davidson) then moves the sediments to within one mile of the coast near the Pajaro River. Several pockets of sediment concentration appear in the southern bay as represented generally by the A contour. Little of this material is escaping around the Monterey Peninsula. The evidence for this is the close proximity of the lower-valued contours to the Monterey Peninsula. This pattern is confirmed by comparing the map with the original scene. This contour map, however, results in a much more detailed picture of subtle radiance differences. This allows for detailed interpretation of sediment distribution patterns in the offshore area. This contouring technique is discussed in Section 2.6.



EXPLANATION

CONTOUR	RADIANCE 1:128
1	13.000000
2	14.000000
3	15.000000
4	16.000000
5	17.000000
6	18.000000
7	19.000000
8	20.000000
9	21.000000
A	22.000000
B	23.000000
C	24.000000
D	25.000000
E	26.000000
F	27.000000
G	28.000000

Figure 2

Figure 3. San Francisco - U-2 Photography. This photograph was taken on 3 April 1973 at an altitude of 65,000 feet. Sediment transport and current activity in the Gulf of the Farallones are shown in detail. The wake of the ship at Point 1 shows clearer subsurface waters being mixed with the thin layer of sediment-laden surface water. The gyre of material in the Gulf of the Farallones indicates by the dashed line, Point 2, is approximately 5.5 miles across and is moving in a clockwise direction (the Golden Gate Bridge is one mile across). The location of this gyre on the photography confirms findings determined during this study (Section 2.2) and measurements made by the U. S. Army Corps of Engineers (1971). The movement of this material reflects the influence of the upwelling period. During the season March through July the coastal currents and the littoral drift regime in the vicinity of the San Francisco Bar are directed up-coast along the outside contour of the Bar. The San Francisco Bar forms an arc approximately 5 miles in diameter off the outer entrance to San Francisco Bay. At the Golden Gate Bridge the current is moving into San Francisco Bay at 3.7 knots and is within one hour of maximum flood. At a distance of 500 yards off Pt. Bonita (Point 3) and 400 yards off Pt. Lobos (Point 4) sharp boundaries between the sediment laden flood waters and the clearer nearshore waters is evident. To the north along the coast the clearer waters appear to be a result of an upwelling. To the south of the entrance, this boundary is a result of wind drift, wave-induced current and changes in the depth and gradient of the Bar. To the west (left), a definite boundary is present which separates the lighter coastal sediment laden water and darker "open ocean" waters. Several wave train directions are also visible, trending N-S, NE-SW and E-W. Wave refraction is clearly visible at the Bay entrance and south along the San Francisco coast. The sun glitter pattern emphasizes the wave direction. A wake is present adjacent to Mile Rock off Pt. Lobos (right of Point 4) as a result of the high current velocity. This type of imagery is used as background in the ERTS data analysis.

Figure 3. San Francisco - U-2 Photography

2.0 CALIFORNIA COAST NEARSHORE PROCESSES

2.1 DAVIDSON CURRENT PERIOD

The complex movements of the various surface currents which occur during the Davidson Current Period are illustrated in Figure 4. The information for this plot comes from repetitive ERTS coverage, several aircraft flights and sea truth sources. Figure 5 is a mosaic of channel 4 (5000-6000 Å) ERTS imagery which includes scenes judged to most clearly delineate the relative concentrations and dispersal of suspended sediment. The time period covered by these figures is mid-November 1972 - February 1973 and the imagery utilized is shown in Figure 6. Although this California coast mosaic covers areas outside the designated test cells (Humboldt Bay, San Francisco, Monterey Bay, Santa Barbara Channel and San Pedro Channel) it was found that the entire coast must be analyzed in order to understand the cell nearshore features. The main influencing current on the coast is the California Current which is a part of the great clockwise circulation of the North Pacific Ocean. However, during the period of approximately November to February each year, the Davidson Current--a north moving counter-current--is the dominant inshore transporter of water and suspensates.

The Davidson Current is generally a deep counter-current below 200 meters which flows to the northwest along the coast from Baja California to some point beyond Cape Mendocino. It brings warmer, more saline water great distances northward along the coast. When the north winds are weak or absent in late fall and early winter this counter-current forms at the surface, well on the inshore side of the main stream of the California Current. The evidence for this current is visible on the mosaic and indicated by the temperature contours (Figures 7 and 8) and current measurements collected from this area. The temperature contours in the eastern Pacific bend to the north along the coast during the height of the Davidson Current activity with the most dramatic changes taking place in February. Figures 9-13 are illustrations of aircraft imagery which show details of the effect of the Davidson Current.

In comparing Figures 7 and 8 the north trending temperature movement is illustrated. These two figures show sea surface temperature (°F) for the first half of the months of January and February 1973. This corresponds to the period when the ERTS imagery was collected for the Davidson Current Period mosaic. A good example of the effect that occurs during this period is illustrated by the 54° contour. On Figure 7 this contour, which trends generally NW-SE, meets the California coast just north of San Francisco. During the next 30-day period the warmer waters from the south move northward along the coast. In Figure 8 the result of this movement is seen as this same 54° contour meets the coast north of Pt. Arena, a distance of over 80 miles.

In general, the Figure 5 mosaic of this period illustrates the greatest concentration of nearshore northern moving sediments offshore to a distance of 3 to 5 miles. At several points along the coast the movement is blocked by large gyres which appear to carry significant volumes of sediment off-coast where they are then transported southward by the California Current. At Pt. Conception a relatively small blockage takes place, but off Pt. Lopez 42 miles south of Monterey an extensive offshore movement of sediment takes place. Initial transport here is in the southwest direction to a point about 60 miles

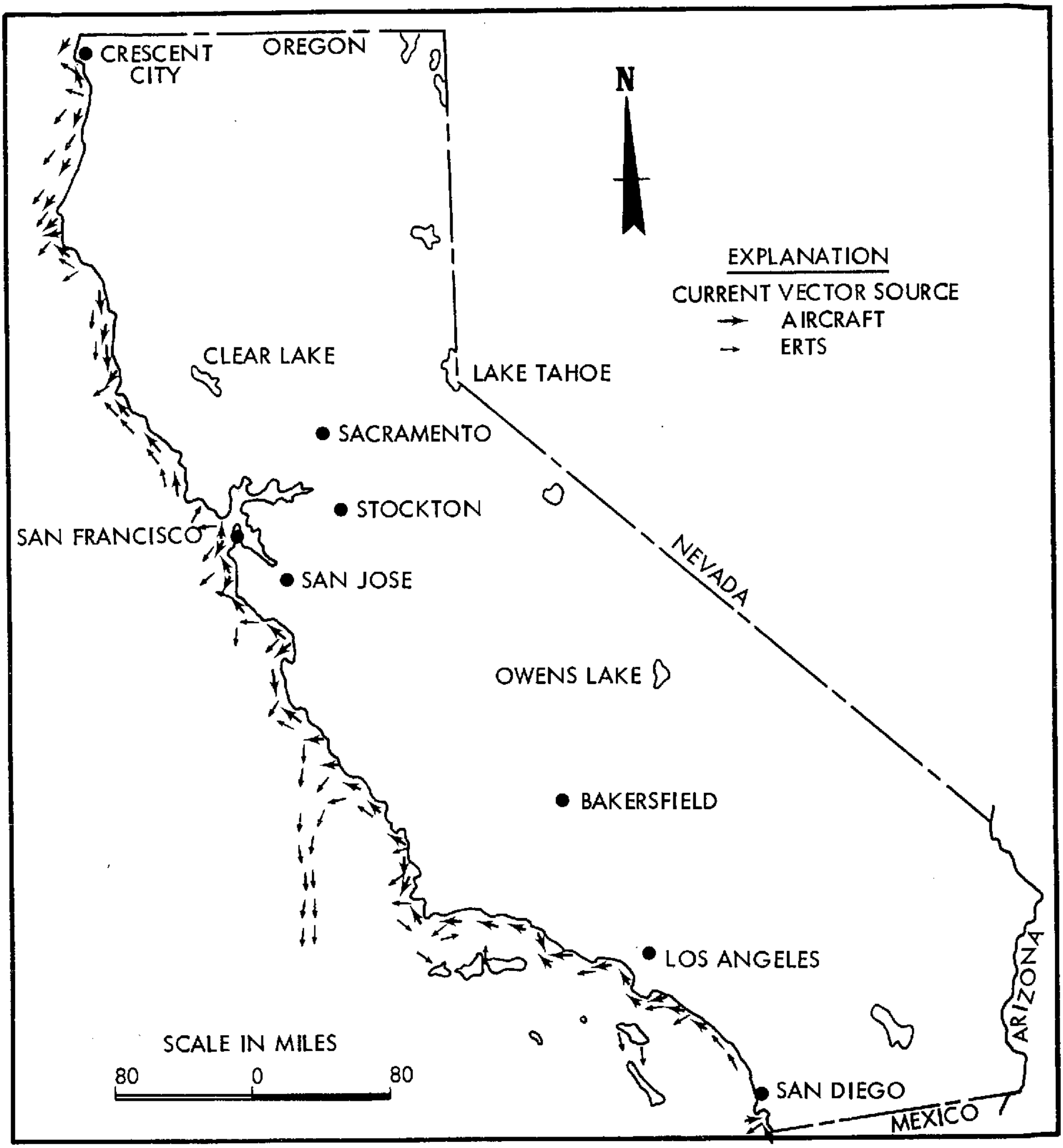
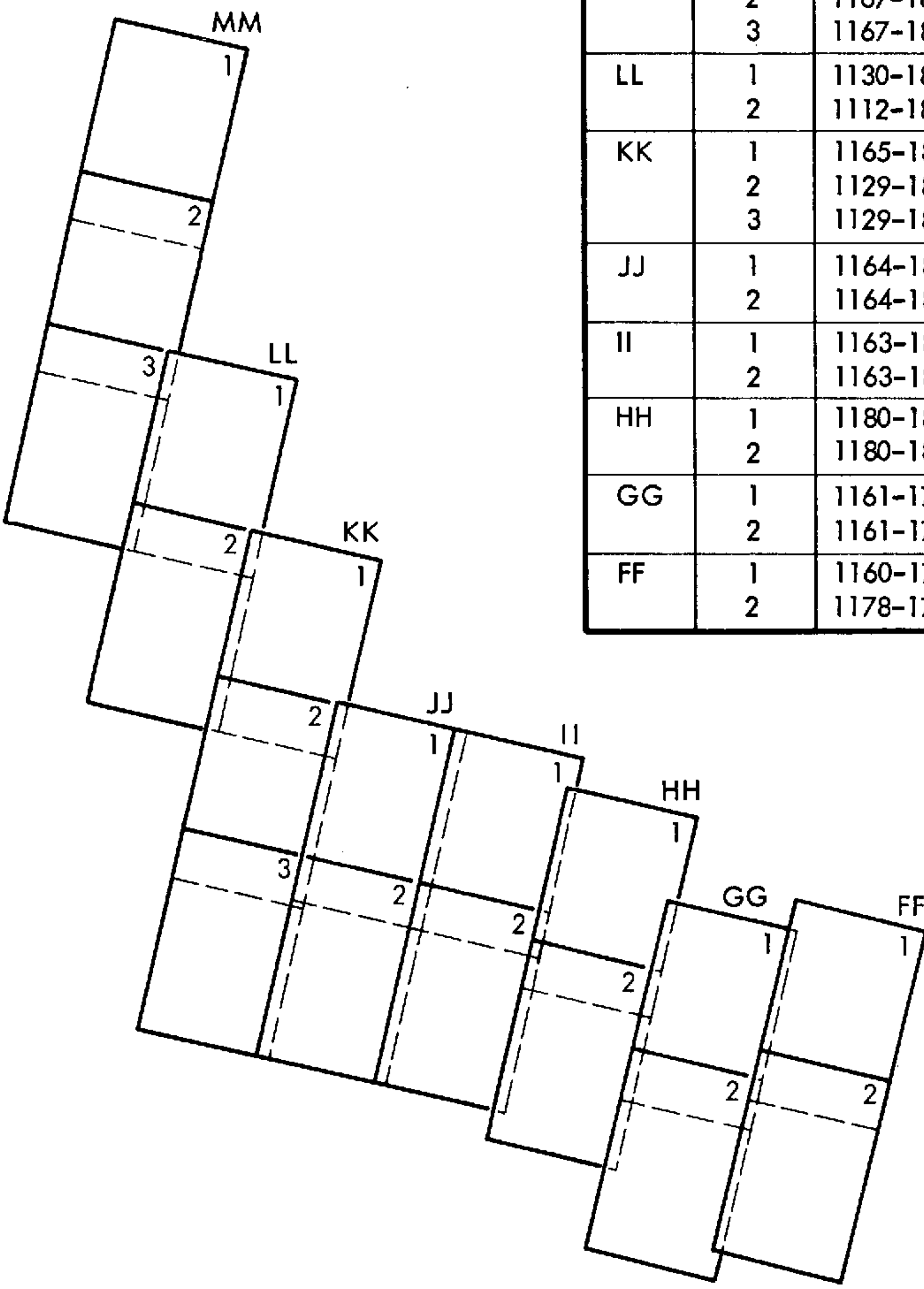


Figure 4. Davidson Current Plot. Nearshore and Coastal Currents Determined from MSS Band 4 (5000 – 6000 Å) Imagery During the November 1972 – January 1973 Period. ERTS Imagery (See Figure 5) Was Supplemented by U-2 and Low Level Aircraft Photography and Sea Truth Data

Figure 5. Davidson Current Period Mosaic

ORBIT	PHOTO NO.	INDEX NO.	DATE
MM	1	1167-18280-4	1/ 6/73
	2	1167-18283-4	1/ 6/73
	3	1167-18285-4	1/ 6/73
LL	1	1130-18235-4	11/30/72
	2	1112-18233-4	11/12/72
KK	1	1165-18175-4	1/ 4/73
	2	1129-18183-4	11/29/72
	3	1129-18190-4	11/29/72
JJ	1	1164-18123-4	1/ 3/73
	2	1164-18130-4	1/ 3/73
II	1	1163-18065-4	1/ 2/73
	2	1163-18072-4	1/ 2/73
HH	1	1180-18013-4	1/19/73
	2	1180-18015-4	1/19/73
GG	1	1161-17561-4	12/31/72
	2	1161-17564-4	12/31/72
FF	1	1160-17503-4	12/30/72
	2	1178-17504-4	1/17/73



MOSAIC LEGEND

DAVIDSON CURRENT PERIOD
NOV. 1972-JAN. 1973

Figure 6

off the coast where movement changes to the south. From that point this plume of sediment is detectable being moved 160 miles to the south to the edge of the presently available imagery. At its southern extent this plume is 35 miles wide. The total area of this feature is approximately 2100 square miles. Similar gyres on smaller scales are present near Pt. Ano Nuevo, Devils Slide, Pt. Arena, Pt. Delgada, and off Humboldt Bay. In each case a counterclockwise gyre is present which carries north-moving nearshore sediments offshore into the south-moving California Current. No attempt has been made to estimate the significant amount of offshore sediment movement occurring during the Davidson Current period.

In the Los Angeles Harbor area material from the Los Angeles, San Gabriel and Santa Ana Rivers are being moved offshore and westward by the influence of the Davidson Current. Inside the harbor itself an east-southeastward current is in effect. Once outside the Los Angeles breakwater a slow moving westward current appears to dominate the nearshore sediment movement. Off Santa Catalina Island, however, transport is in the southeast direction indicating a surface current reversal in the San Pedro Channel. Suspended sediments in Santa Monica Bay ring the bay with a 3 to 5 mile wide border. This ring of sediment appears to be escaping the bay area to the westward around Pt. Dume. This agrees with the general Davidson Current pattern.

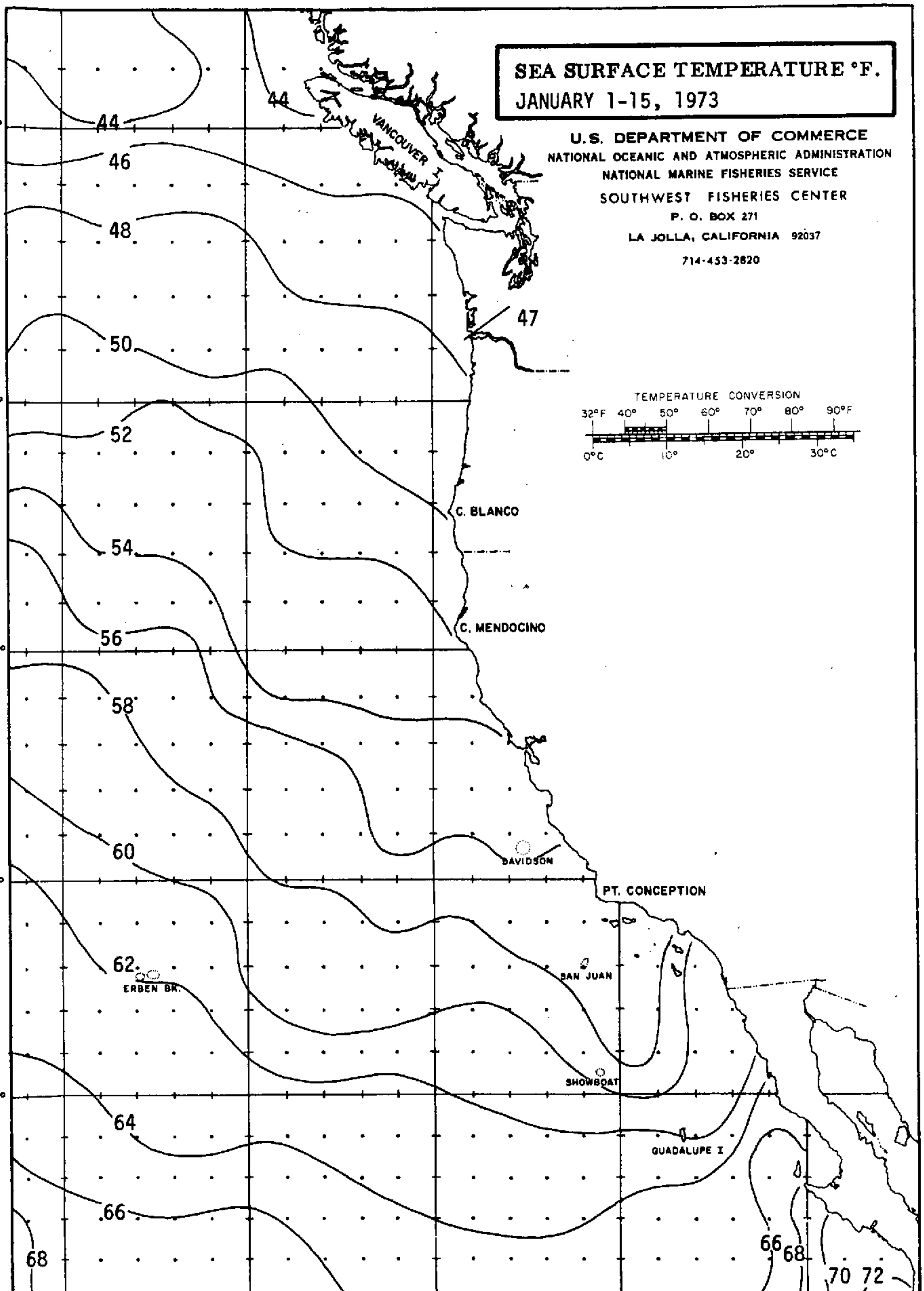
In the Santa Barbara Channel between Port Hueneme and the Anacapa Islands the westward current domination is observed. The pattern with minor modifications continues to west of Carpinteria. A counterclockwise gyre is present just east of Santa Barbara which is moving sediment offshore 4 to 5 miles where they are again moved to the west. Off Pt. Conception the California Counter-Current in the area between the mainland and the Channel Islands as described by Drake (1972) appears to pick up these particules and transports them offshore in a complex pattern where they are influenced by the California Current.

The Monterey Bay surface waters are reported to be exceedingly uniform during the Davidson Current period (CCOFI, 1958). The extreme difference between any pair of stations averages a little less than (0.5°F). No regular pattern of temperature distribution is discernible. The general northern trend of the suspended sediment, however, appears to continue in Monterey Bay as noted on the ERTS imagery. From the area of the Elkhorn Slough north and northwest to Santa Cruz a large gyre of material is present. Little of this material appears to be escaping the confines of the Bay. The blockage of suspensate movement from the Bay appears to be blocked by the counterclockwise gyre activity that is present off Pt. Ano Nuevo.

In the Gulf of the Farallones which encompasses the majority of the San Francisco test cell, a complex surface current and sediment transport system is present. A large clockwise gyre is present off the Golden Gate Bridge reaching from the Lake Merced area northwest to the vicinity of Duxbury Pt. Near Lake Merced a nodal point is present separating the large gyre just mentioned from a smaller gyre present off the Devil's Slide. From Duxbury Pt. toward Drakes Bay the current appears to be moving sediment in a northwest direction. Near Drakes Bay this current meets a counterclockwise moving current which generally moves around Pt. Reyes. Just north of Pt. Reyes

at the mouth of the Russian River the distinct northern effect of the Davidson Current is illustrated. The majority of the movement takes place within 3 to 4 miles of the coast.

The overall affect of the current along the California coast can be viewed in detail on the ERTS imagery. Although the general changes in current direction have been known for some years the complexities within the general currents are not recorded in detail. Near the coast the effect of the irregular coastline and varying depth governs detailed transport and current direction. This topography and the winds, which sometimes reinforce and sometimes oppose the current, and the significant vertical motion in the region of upwelling and the oscillations of internal waves, all combine to make the measurement of current complex. The synoptic ERTS view of currents as indicated by sediment tracers presents a unique capability to the coastal investigator.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JANUARY 1-15, 1973
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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
SOUTHWEST FISHERIES CENTER
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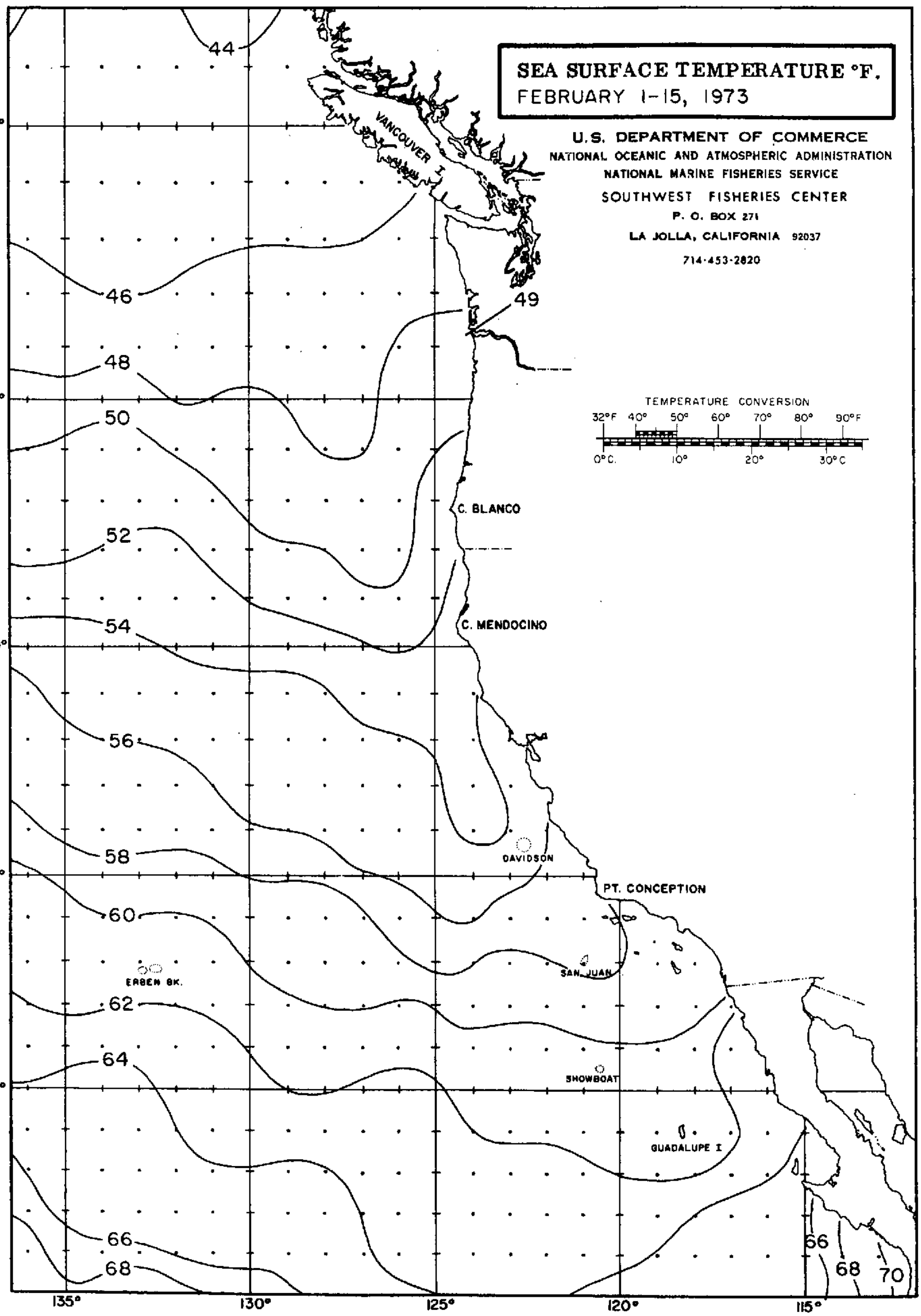
Figure 7.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115°

Figure 8.

Figure 9. Crescent City Area High Altitude Infrared Color. The picture was taken from approximately 65,000 during the Davidson Current Period. Crescent City, California is just east (left) of Pt. St. George in the center of the picture. The oblique view is southeast along the California coast. A gyre is set up of Pt. St. George moving sediment from the Smith River (foreground) counterclockwise toward Crescent City. Island wake are visible south of the St. George Reefs. Large amounts of suspended sediment is being discharged from the Klamath River seen south of Crescent City. The dominant current in the area is the south moving California Current.

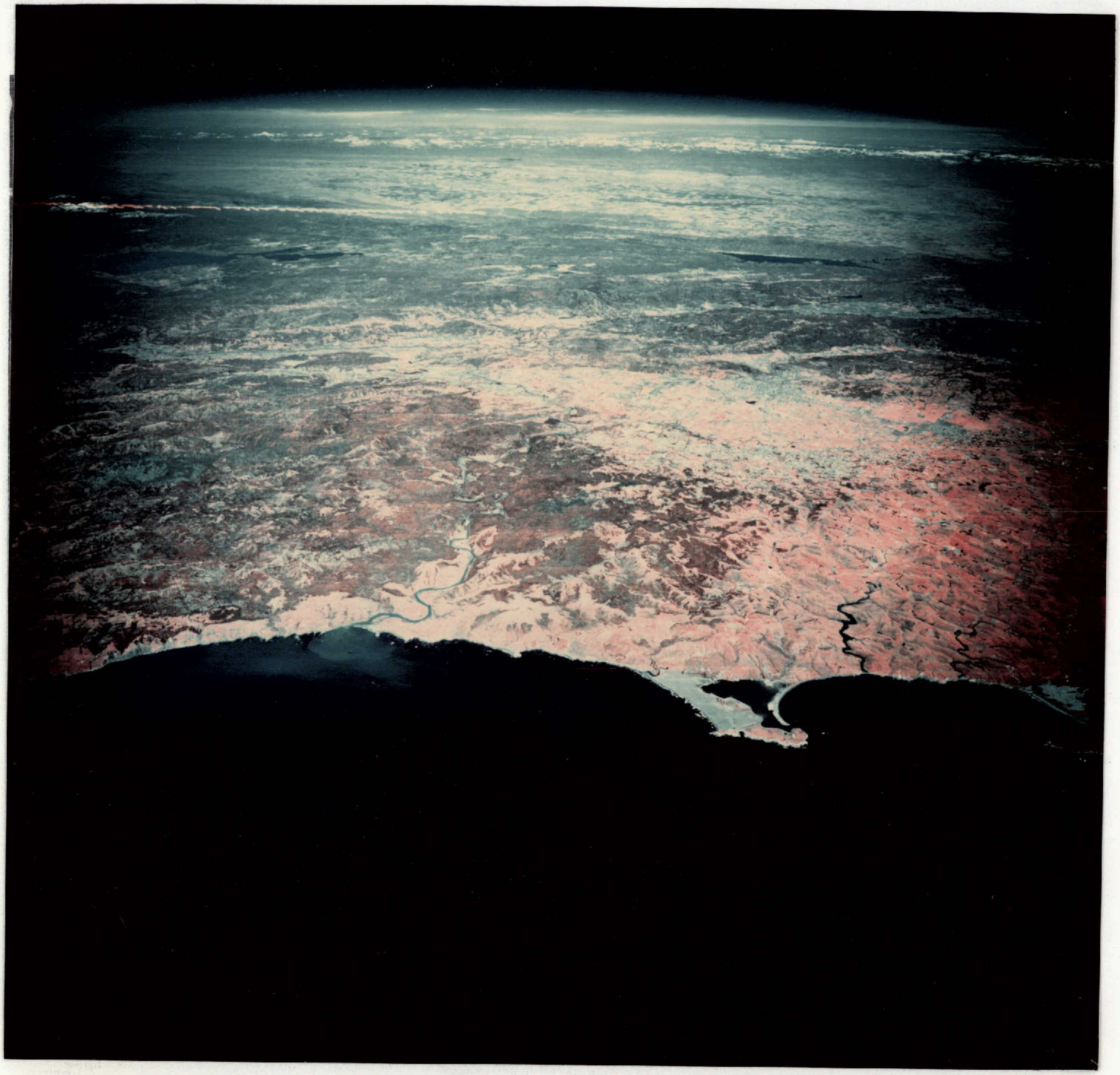

Figure 10. Russian River - Bodega Head High Altitude False Color. Looking east across the Russian River mouth (left) and Bodega Head (right) toward the Sierra Nevada Mountains (horizon). Discharging sediment from the Russian River is moving offshore in visible lobes then northward. The Davidson Current effect is clearly seen. This oblique picture was taken at 65,000 feet.

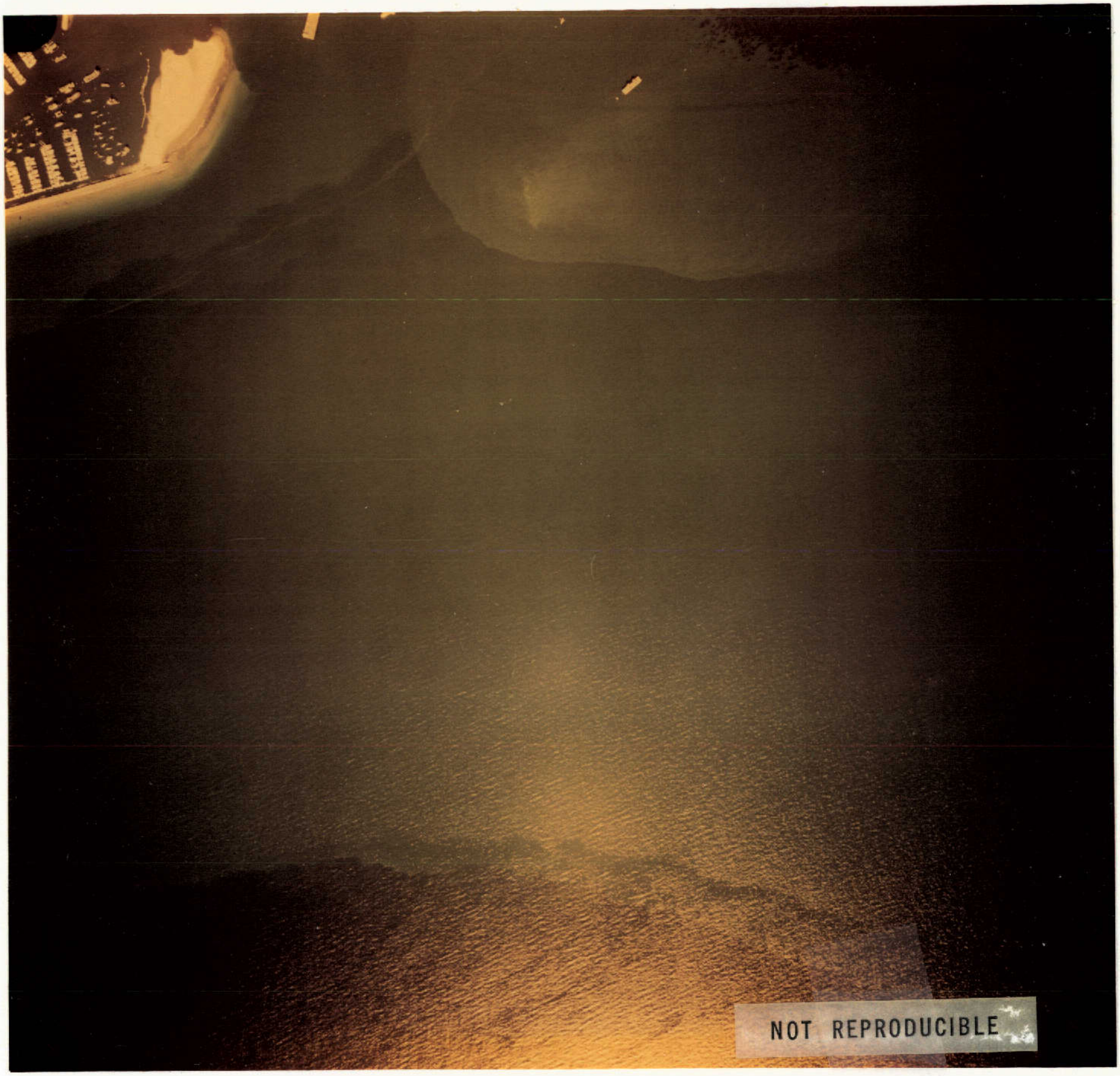

Figure 11. Santa Barbara Harbor. This picture was taken using color film, filtered with a Wratten 12 filter, and overexposed one f-stop. This technique was found to give useful information for the analysis of current and sediment patterns. Located in the upper left is Santa Barbara Harbor. Good depth delineation is noted on the shoreward side of the Santa Barbara sandspit. Longshore sediment movement to the SE is visible near the harbor and offshore (bottom of picture). Also effluent from the Santa Barbara Sanitary Outfall is clearly seen surfacing seaward (right) of the harbor. The effluent is moving east and north toward the coast. This east moving current adjacent to Santa Barbara is often present even during the Davidson Current Period. This picture was taken on December 24, 1972 from an altitude of 10,000 feet. Kelp is visible in the upper right corner of the picture.

Figure 12. Infrared Thermal Imagery - San Francisco Area. This infrared thermal imagery was collected on 26 January 1973. Line A was flown at 10,000 feet while lines B, C and D were flown at 20,000 feet. The relative temperature differences are shown with colder water imaging dark to black and the warmer water imaging light to white. The patterns formed by the mixing of waters of differing temperatures indicate the surface current dynamics.

Line A is a strip along the city of San Francisco and the entrance to San Francisco Bay. Cold water is emptying from the Bay. Mixing and eddy patterns are present in the littoral zone. Line B is located in the same area as A but is stretched from the Bolinas Bay area on the left to Pt. San Pedro on the right. Again the cooler water from San Francisco Bay is mixing with warmer ocean water.

Line C is in the Bodega Head area north of San Francisco. On the left is the Russian River discharging into the ocean. The dominant current direction appears to be to the left (NW). A complex eddy system is present right (SE) of Bodega Head. The waters from Tomales Bay are moving out into the open ocean.

Line D stretches from Pt. Reyes (left) to Bolinas Bay (right). A counterclockwise eddy, that is often present, is visible behind (right) Pt. Reyes. Material moving out of the Gulf of the Farallones often joins these eddys for a period and part of it is temporarily trapped along the coast near Drakes Bay.

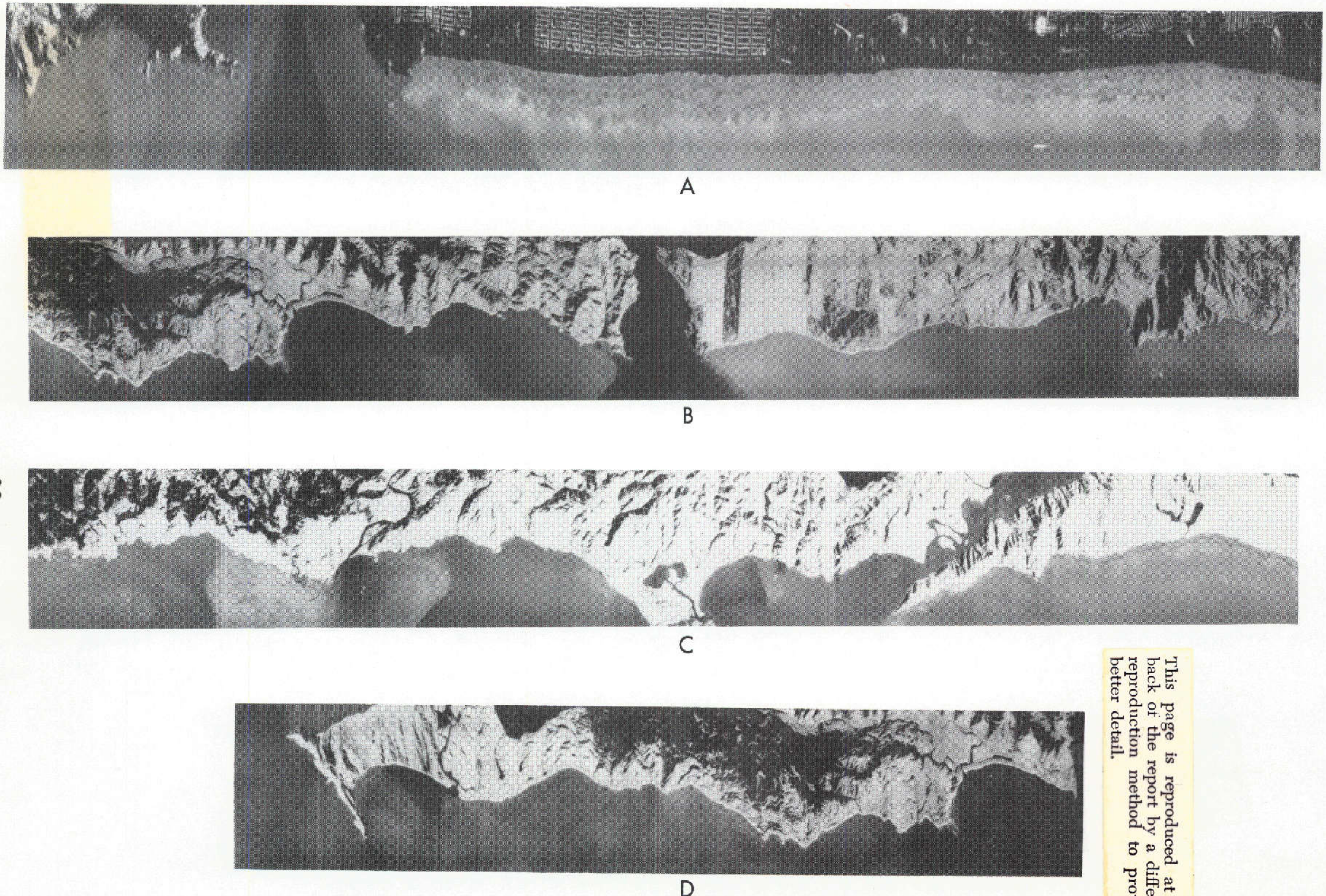

Figure 12. Infrared Thermal Imagery – San Francisco Area 26 January 1973

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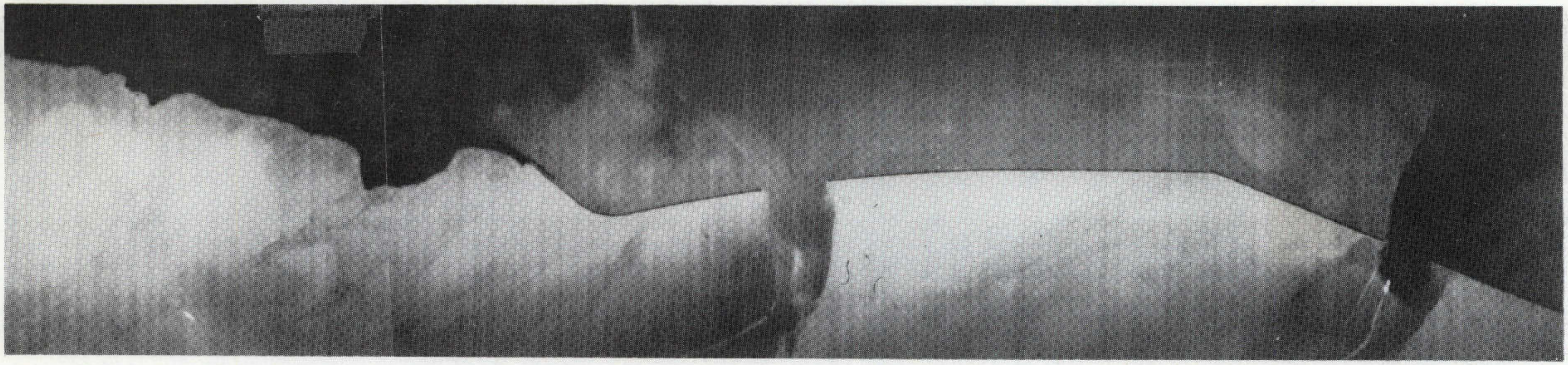
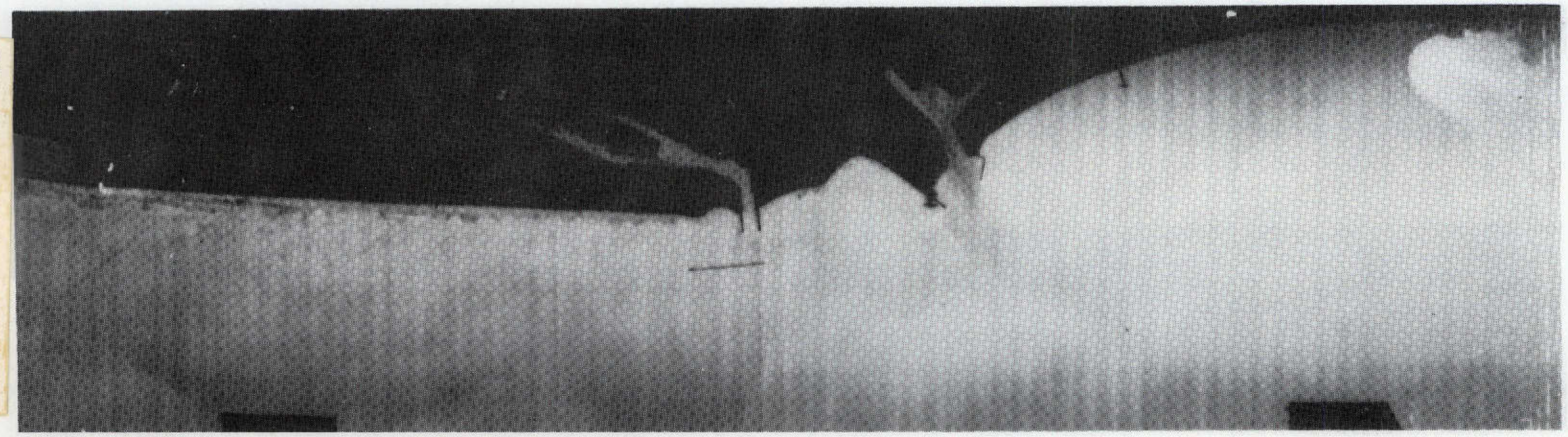


Figure 13. Infrared Thermal Imagery – Los Angeles and Port Hueneme. The upper picture illustrates complex mixing pattern formed outside the Los Angeles breakwater during ebb tide. The Davidson Current is moving the cold waters to the west (left). A boat is entering the Long Beach entrance (right) to the harbor. The lower image was taken in the Channel Island Harbor, Port Hueneme area. Port Hueneme (right) water appears to be moving west (left), while warm effluent water (extreme right) is moving to the right. Such opposite moving currents are often found in this area as a result of coastal eddys. These eddys form as a result of the Anacapa Current and the Southern California Countercurrent. This imagery was collected on January 26, 1973.



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2.2 UPWELLING PERIOD

The Upwelling Period is a markedly seasonal phenomena which takes place generally from mid-February to July. An Upwelling Period Current Plot, Figure 14, resulted from analyzing the ERTS imagery mosaic, Figure 15, for the March-April 1973 period. This mosaic is assembled from ERTS channel 4 (5000-6000 A) frames (Figure 16). The imagery was picked for clarity and visible suspended sediment content which is utilized as a tracer for studying current movement.

During the Upwelling Period winds parallel to the coast move surface waters offshore allowing deeper ocean water to surface. This effect seems to be intensified south of capes and points which extend out into the current stream and above submarine canyons. On the current plot, Figure 14, this process is illustrated as upwelling are located at Crescent City, Cape Mendocino and south of Pt. Conception, Half Moon Bay and Monterey Bay. These colder upwelling waters are often rich in nutrients with the additional result that phytoplankton blooms often accompany this period. This is often accompanied by increases in the fish population which is obviously of great interest to the fishing industry.

An illustration of the effect of upwelling on the California coast surface temperatures is shown on Figure 17. During the April 16-30, 1973 period gradual warming is taking place to the south along the coast with the exception of the Cape Mendocino area. An extensive upwelling extends from near Crescent City to south of San Francisco is an variation to the general warming trend. Similar type features on a more local scale are detectable by studying offshore tonal changes on the ERTS imagery. Confirmation of coastal processes during this period resulted from aircraft and sea truth measurements similar to the Davidson Current period. Figure 18 is a U-2 photograph of the Humboldt area which illustrates in detail a complex nearshore sediment transport pattern and a possible upwelling. Figure 19 is a set of infrared thermal scanner images of the Russian River-Pt. Reyes taken during the Upwelling Period. Figure 20 is a yellow-filtered color photograph of Port Hueneme-Channel Island Harbor which illustrates the coastal erosion at that location.

As in the Davidson Current mosaic, the major features visible are large offshore transport cells which join the south moving California Current. The largest transport cell is visible off Pt. Conception. This feature stretches for 130 miles off the coast to the edge of the available ERTS imagery. This Pt. Conception feature (imagery date 3/15/73) is 105 miles further south along the coast from the parallel "Lopez Point" transport cell (imagery date 11/29/72) noted on the Davidson Current mosaic.

In addition a number of smaller offshore transport systems are also present. They include features off: Half Moon Bay, Humboldt Bay, the Eel River over Pt. St. George. The total volume of offshore sediment movement during this Upwelling Period appears to be a significant loss in the California coast sediment budget.

In Monterey Bay suspended sediment from the Salinas River is moving northward to the vicinity of the Pajaro River. Upwelling above the Monterey Canyon is resulting in the shoreward transport of sediment adjacent to Moss Landing.

The effect that upwelling has on the nearshore coastal sediment transport is emphasized and illustrated on the ERTS imagery mosaic. In reviewing historical data on upwelling, it is noted that the exact location of these features are not predictable. The importance of this information to both the understanding of nearshore processes and to the fishing industry is apparent.

By interpreting the tonal contrasts present on the ERTS imagery it appears that a great deal of useful information can be obtained on the Upwelling Period.

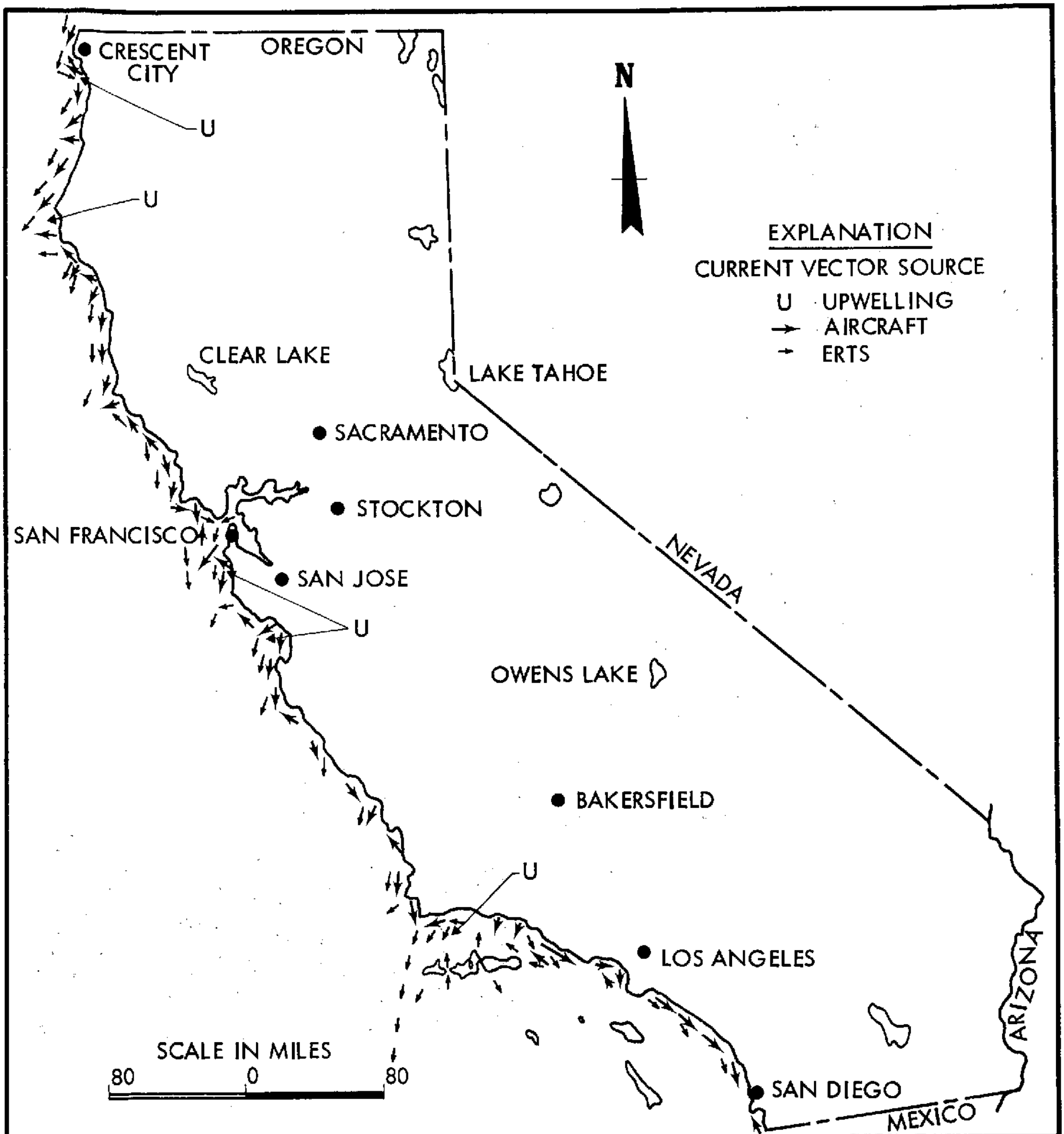

Figure 14. Upwelling Period Current Plot. Nearshore and Coastal Currents Determined from MSS Band 4 (5000 - 6000 Å) Imagery, U-2 and Low Level Aircraft Photography and Sea Truth (See Figure 15)

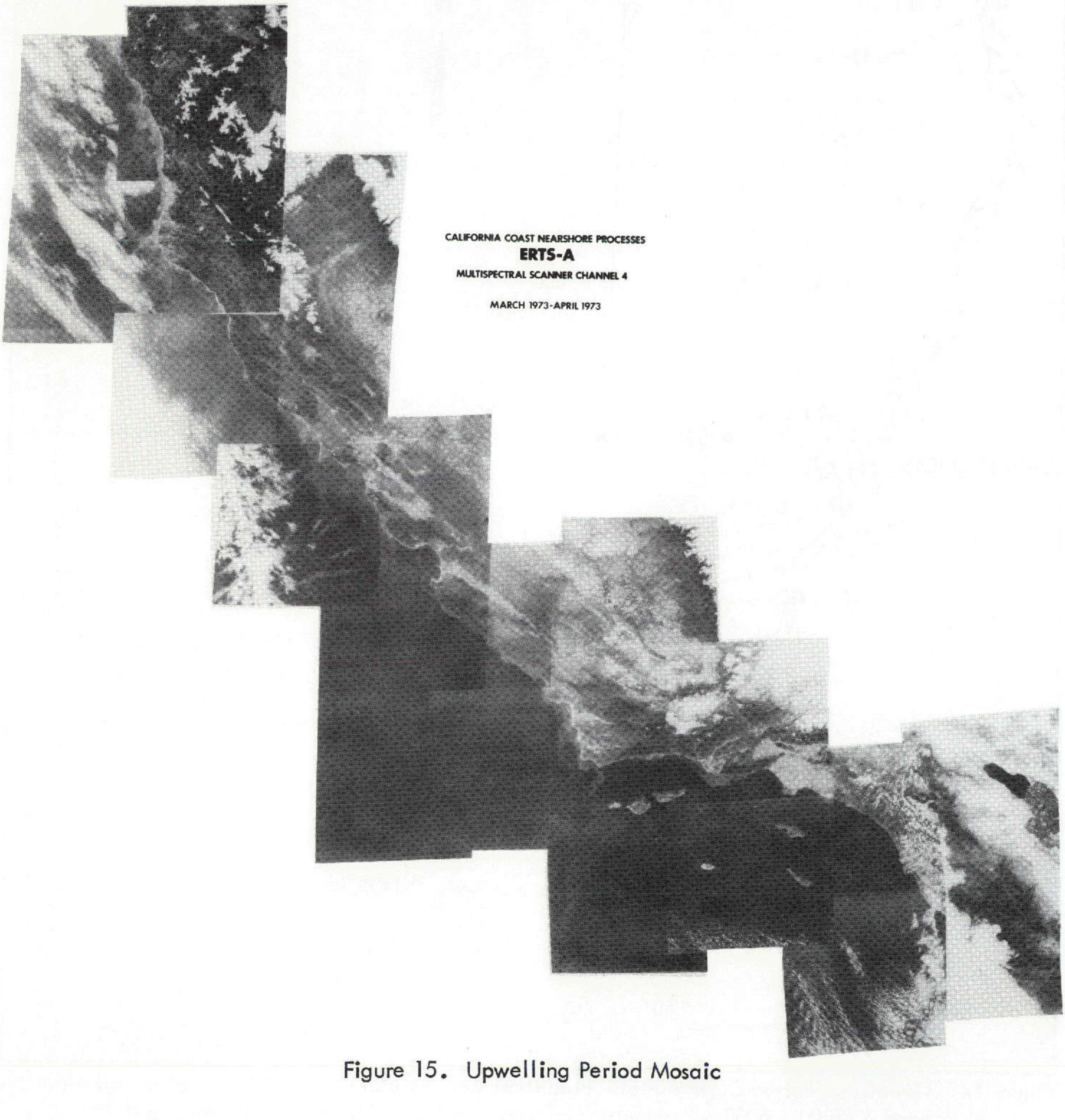

Figure 15. Upwelling Period Mosaic

MOSAIC LEGEND

UPWELLING PERIOD
MARCH-APRIL 1973

ORBIT	PHOTO NO.	INDEX NO.	DATE
NN	1	1258-18343-4	4/ 7/73
	2	1258-18345-4	4/ 7/73
MM	1	1275-18284-4	4/24/73
	2	1275-18290-4	4/24/73
	3	1257-18294-4	4/ 6/73
LL	1	1238-18233-4	3/18/73
	2	1238-18235-4	3/18/73
	3	1238-18242-4	3/18/73
KK	1	1255-18183-4	4/ 4/73
	2	1255-18190-4	4/ 4/73
	3	1255-18192-4	4/ 4/73
JJ	1	1254-18131-4	4/ 3/73
	2	1254-18134-4	4/ 3/73
II	1	1235-18073-4	3/15/73
	2	1235-18075-4	3/15/73
	3	1235-18082-4	3/15/73
HH	1	1234-18021-4	3/14/73
	2	1234-18023-4	3/14/73
GG	1	1269-17565-4	4/18/73
	2	1269-17571-4	4/18/73
FF	1	1268-17510-4	4/17/73
	2	1268-17513-4	4/17/73

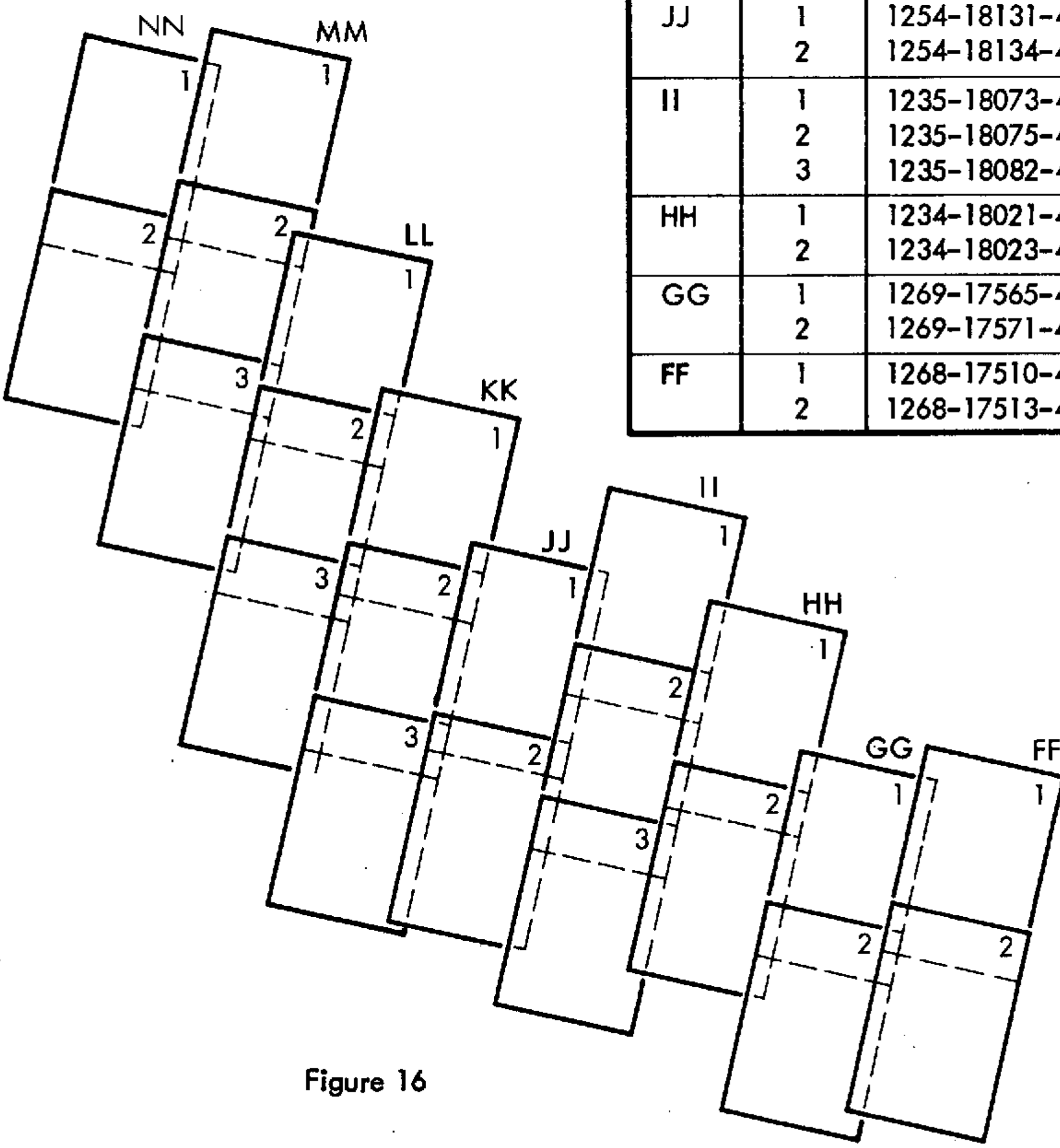

Figure 16

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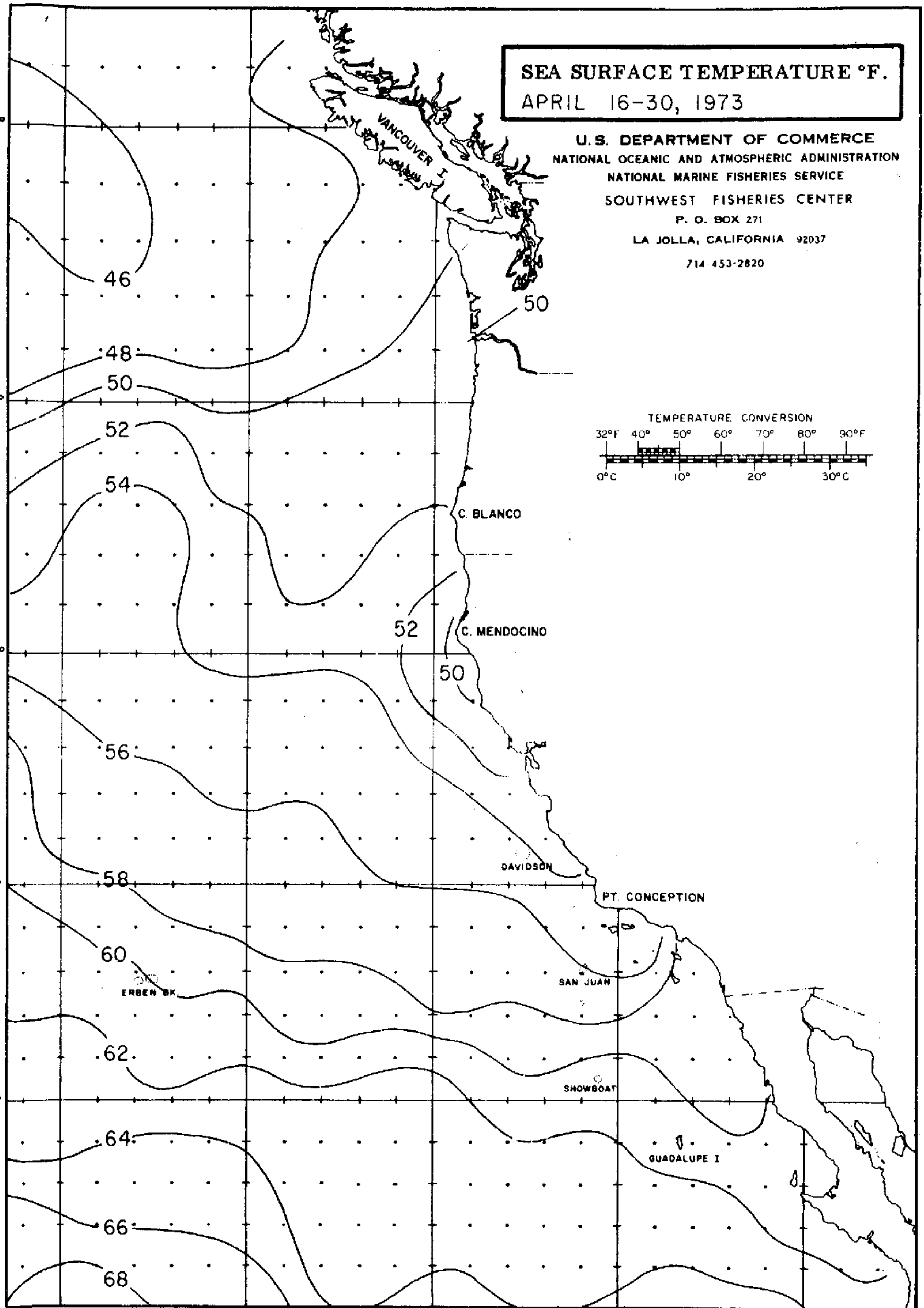


Figure 17

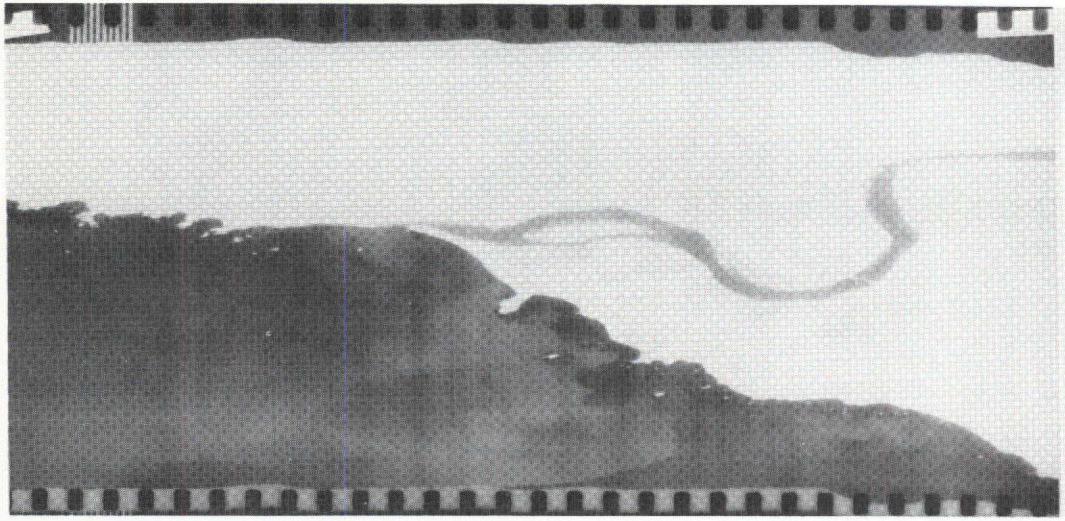
Figure 18. Humboldt Bay - U-2 Photography. Offshore effluent patterns and several boundaries caused by longshore currents are visible in detail in this picture. Humboldt Bay and Eureka, California are located in the right center of this photograph which was taken at 65,000 feet on 3 April 1973 at 0930. The current is moving at 2.4 knots (Tidal Current Tables, 1973) in a southern direction as evidenced by the effluent dispersion at points 1 and 2. This material which comes from industrial plants is being transported to within 1 mile of the entrance to Humboldt Bay. Dissipation of this material accounts for loss of visible indication of its further movement. Three distinct NE-SW suspended sediment boundaries are present paralleling the coast at points 3, 4 and 5. Their respective distances from the coast are: 1.2 miles (3), 2.5 miles (4) and 8.0 miles (5). Boundary 3 appears to result from a combination of longshore sediment movement and bottom topography. Rip currents at 6 are moving through the breaker zone. Several wave defraction patterns are visible inside the entrance to Humboldt Bay and two sand spits built up by these patterns are visible at 7 and 8. At point 9 an apparent small upwelling is bringing clearer subsurface waters to the surface where they are being moved southwest. The sediments are primarily from the Mad and Klamath Rivers as indicated on northern photographs in this series.

Figure 18. Humboldt Bay – U-2 Photography

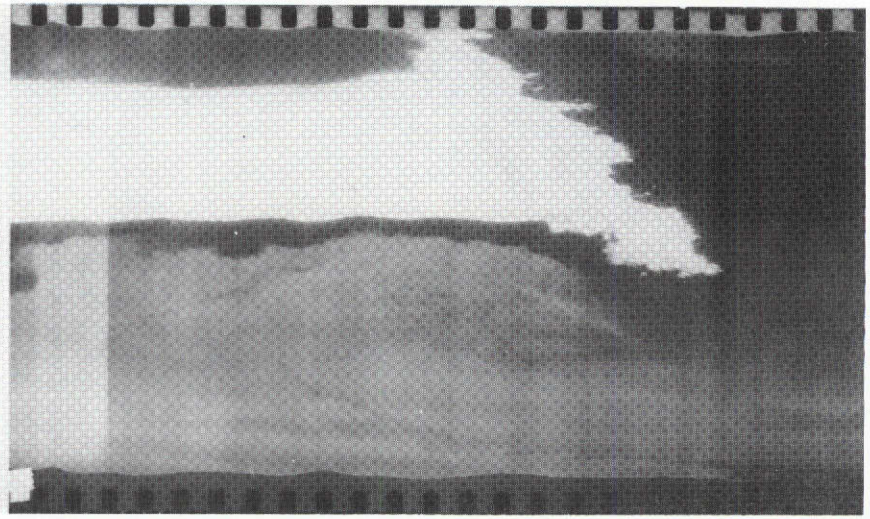
Figure 19. Russian River - Pt. Reyes IR Thermal - April 4, 1973. The discharge of the Russian River is shown in A. The dominant current movement of the lighter group (warmer) river waters was to the south (right). After passing the point of land south of the river mouth offshore movement is evident. Several temperature lobes appear. Cooler (darker) water is present just south of the point of land representing a possible upwelling. Scenes B and C both show Pt. Reyes. In analyzing photographic images of this area a gyre of sediment just off the point is often noted. This infrared thermal image shows a similar feature. A clockwise thermal anomaly is present just west (left in C) of Pt. Reyes. A linear trend of warmer water also appears moving southeast (right in C) into the Gulf of the Farallones. A colder water upwelling south of Pt. Reyes may be causing the gyring effect present in these two scenes.

This imagery displays thermal anomalies as detected and recorded by an LN3 Thermal Mapper. This system is a single channel electro-optical line scanner. Emitted energy in the 8-14 micron portion of the spectrum was collected by a rotating mirror scanning perpendicular to the direction of flight. Thus, providing the "X" dimension in the above scenes. The "Y" dimension was provided by the aircraft's motion. The IR energy received was optical focused on a HgCdTe detector for thermal IR sensitivity. The resultant electrical signals were processed through associated electronics for either direct recording onto film or recording onto magnetic tape for post-flight data processing. The example scenes are positive prints of the in-flight original films.

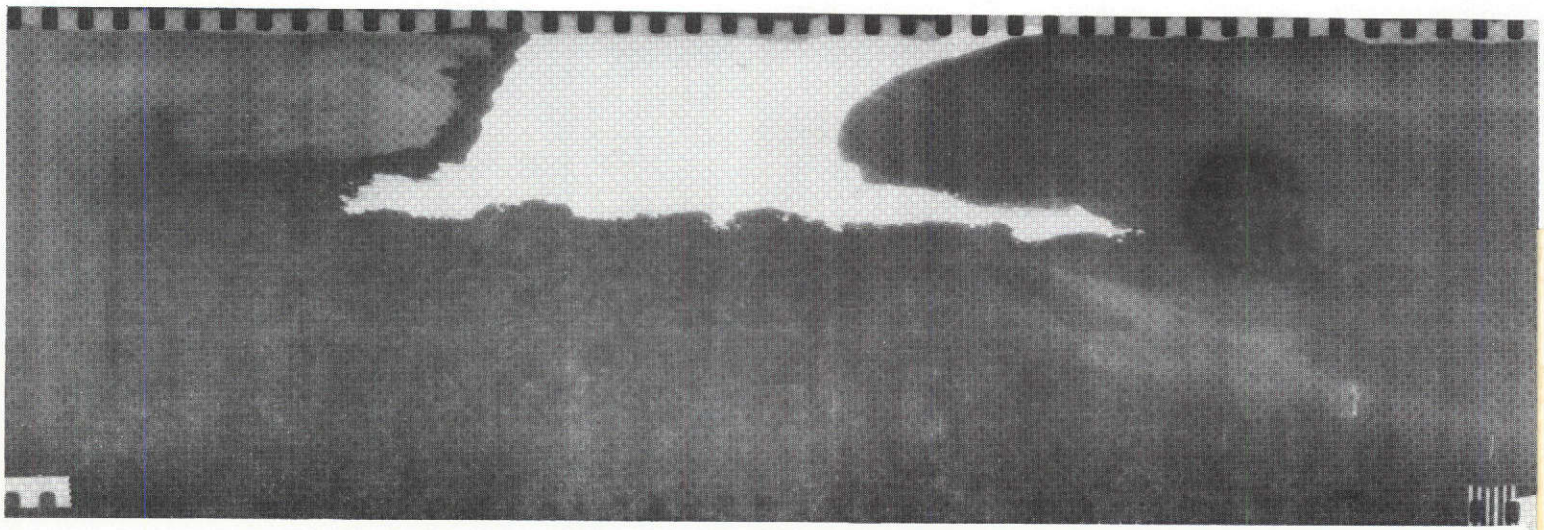
On the edge of each scene is a strip of a constant shade of gray. This gray scale level or signal level on the analog tape represents a reference temperature. This temperature is adjustable and is set to the median scene temperature during data collection for the above examples. This reference temperature was set at 17°C. A calibrated gray wedge was also generated. Thus, the absolute temperature of any point in a scene is known by correlating densities within the scent to the calibrated wedge.



A



B



C

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Figure 19. Russian River - Pt. Reyes IR Thermal - April 4, 1973

Figure 20. Channel Island Harbor - Yellow Filter Color. This yellow filtered (Wratten 12) color photograph of Channel Island Harbor and Port Hueneme was taken April 2, 1973 at 5000 feet. Movement of sediment across the entrance to the harbor and inside the breakwater is illustrated. The erosion of the beach behind the breakwater results from the interaction of the dominant eastern swell, the beach profile and the breakwater. Wave defraction at the entrance to Port Hueneme is brought out in detail by the sun glitter pattern. This picture was taken with a Hasselblad camera with a one f-stop over-exposure. The yellow Wratten 12 filter or overexposed color film was found to give the mose useful information for the analysis of current and sediment patterns.

Figure 20. Channel Island Harbor - Yellow Filter Color

2.3 TRANSITION PERIOD

The Transition Period consists of a description of sediment transport and coastal current for the California coast during the period May-July 1973. This period brackets the end of the Upwelling Period and the beginning of the Oceanic Period, thus it is called the Transition Period. The excellent imagery available represented an opportunity to analyze the coastal waters surface dynamics between the slowing of the upwelling and the nearshore dominance of the California Current. As shown on Figure 21, the current along the California coast was generally south during the Transition Period. The mosaic of this period (Figures 22 and 23), however, illustrates several areas which were not following this simplified pattern.

Analysis of the Transition Period mosaic indicates several areas of complex offshore sediment transport and gyre activity. These include: Cape Mendocino, Pt. Arena, the Gulf of the Farallones, Pt. Conception, Palos Verdes Peninsula, and San Diego. The period represented by this mosaic corresponds to the dry season along the majority of the coast. For this reason there is less riverine discharge and less suspended sediment in the nearshore and offshore area. Erosion of coastal beaches and sea cliffs by longshore currents and storm waves plus natural summer stream runoff still provide sufficient material for detection by ERTS. The major data source for this period's current plot was primarily from ERTS since few aircraft flights occurred during May and June.

The temperature plot for the eastern Pacific Ocean shown on Figure 24 illustrates the effect of this period. In June 1973 the temperature contours are bending south from the latitude of approximately 40°N. However, an upwelling along the northern California coast is still persisting, keeping water temperatures near San Francisco at 54°F. Figure 25 is a color infrared picture of northern San Francisco Bay. It illustrates the movement of sediment into northern San Francisco Bay in the vicinity of Mare Island.

The California Current which is always present off the California coast and which is coming into inshore dominance during this period is an eastern Pacific boundary current. It can be described as a meandering, diffuse southward flow, with short-term variations in speed that are of the same order as the mean speed itself. This current which starts south from the area of the Aleutian Islands is modified by upwelling, solar heating, river discharge and exchange with estuaries and embayments. The speed of this current is usually less than half a knot (CCOFI, 58). The complex meanderings and changes which occur along the path of the California Current are at least partially detectable by analyzing these ERTS images.

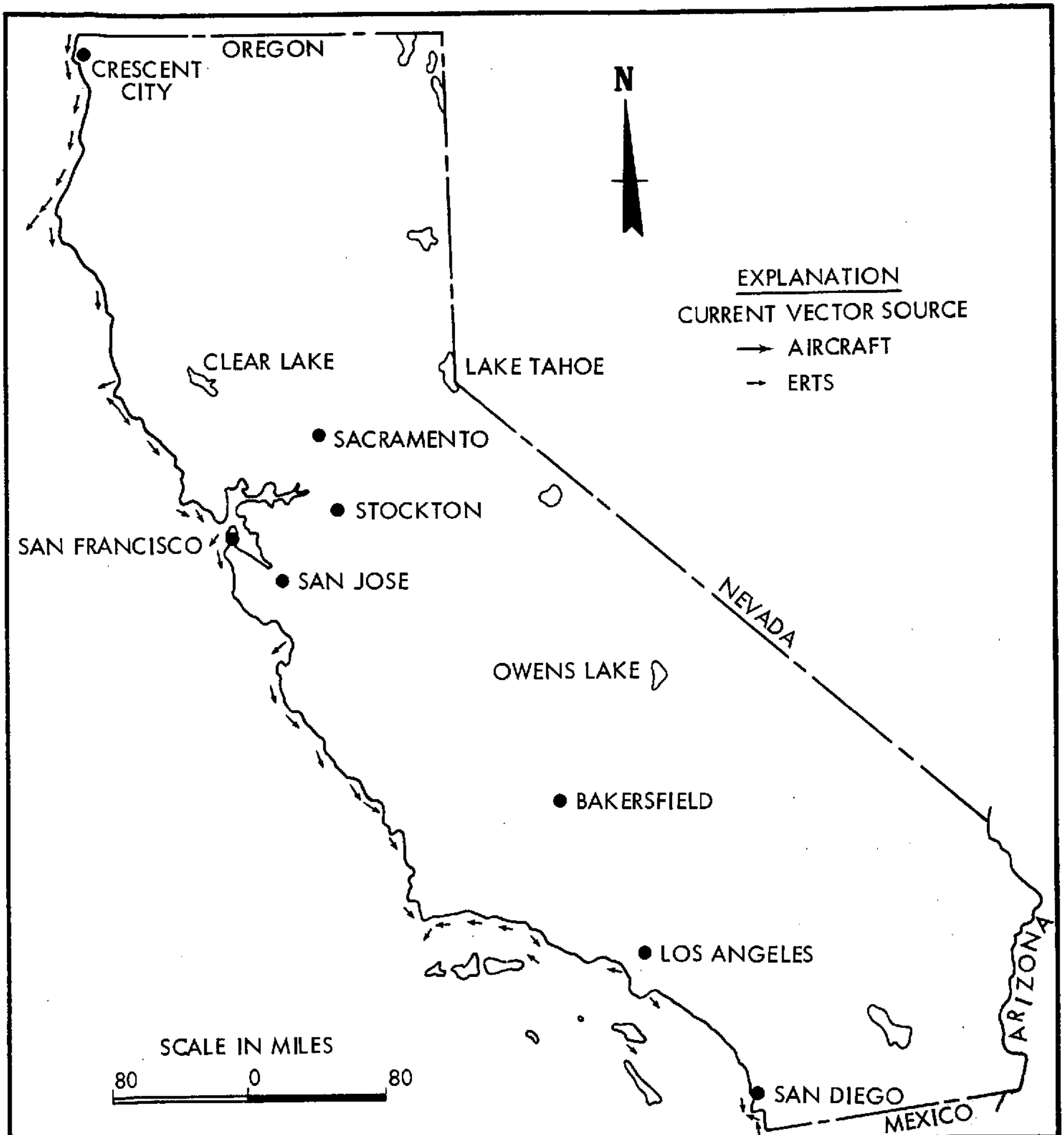


Figure 21. Transition Period Current Plot. Nearshore and Coastal Currents Determined from MSS Band 4 (5000 – 6000 Å) Imagery During the May to July 1973 Period. This represents the Last Two Months of the Upwelling Period and the Beginning (Late July) of the Oceanic Period. Seasonal Lack of Offshore Sediments During This Period Results in Fewer Plotted Currents

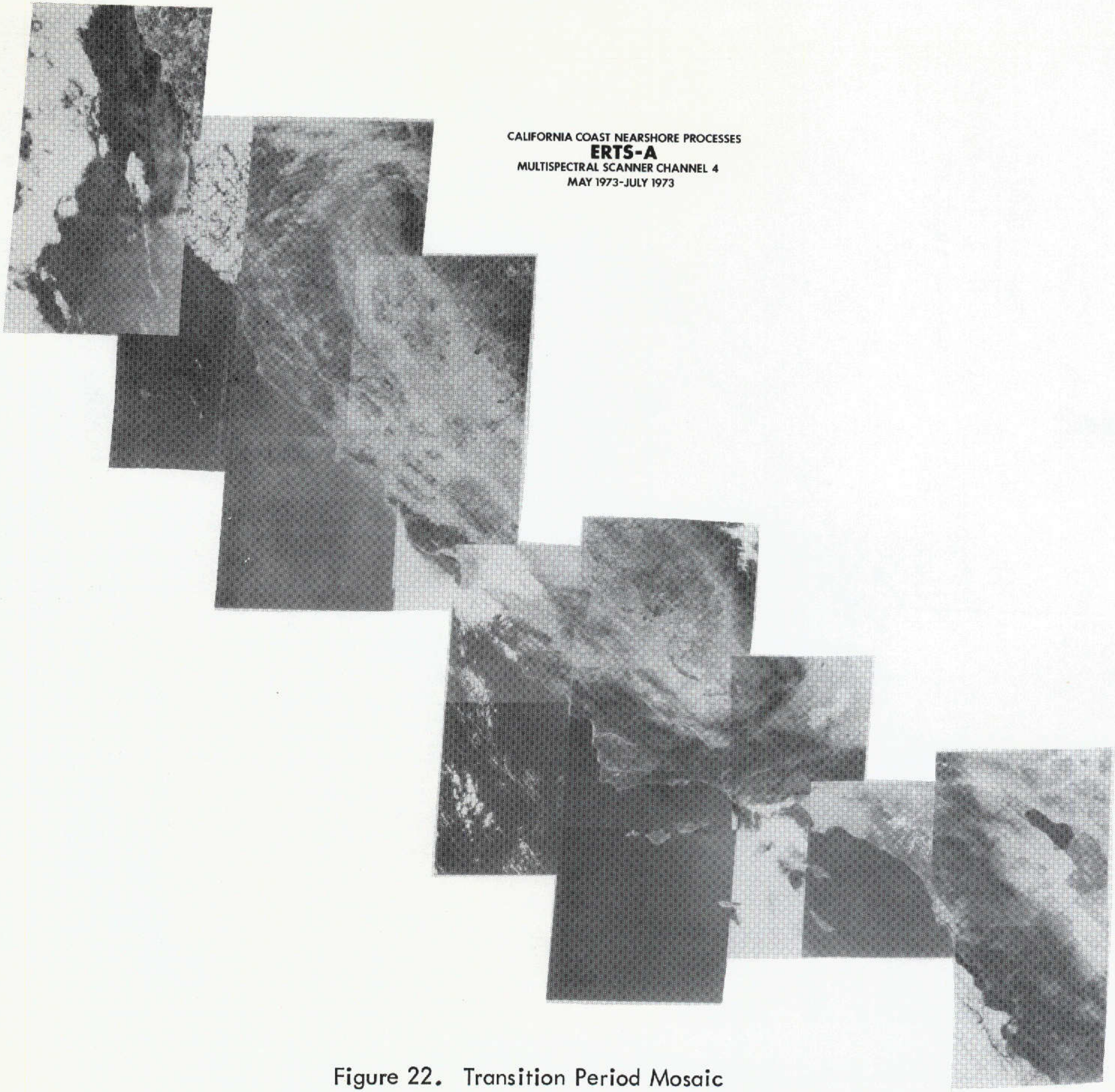


Figure 22. Transition Period Mosaic

MOSAIC LEGEND

TRANSITION PERIOD
MAY-JULY 1973

ORBIT	PHOTO NO.	INDEX NO.	DATE
NN	1	1348-18334-4	7-6-73
	2	1348-18340-4	7-6-73
MM	1	1329-18283-4	6-17-73
	2	1329-18290-4	6-17-73
LL	1	1364-18222-4	7-22-73
	2	1364-18225-4	7-22-73
	3	1364-18231-4	7-22-73
KK	1	1345-18172-4	7-3-73
	2	1345-18174-4	7-3-73
JJ	1	1326-18124-4	6-14-73
	2	1308-18131-4	6-27-73
II	1	1325-18065-4	6-13-73
	2	1307-18073-4	6-26-73
	3	1306-18080-4	6-26-73
HH	1	1324-18014-4	6-12-73
	2	1288-18022-4	5-7-73
GG	1	1269-17565-4	4-18-73
FF	1	1322-17503-4	6-10-73
	2	1304-17511-4	5-23-73

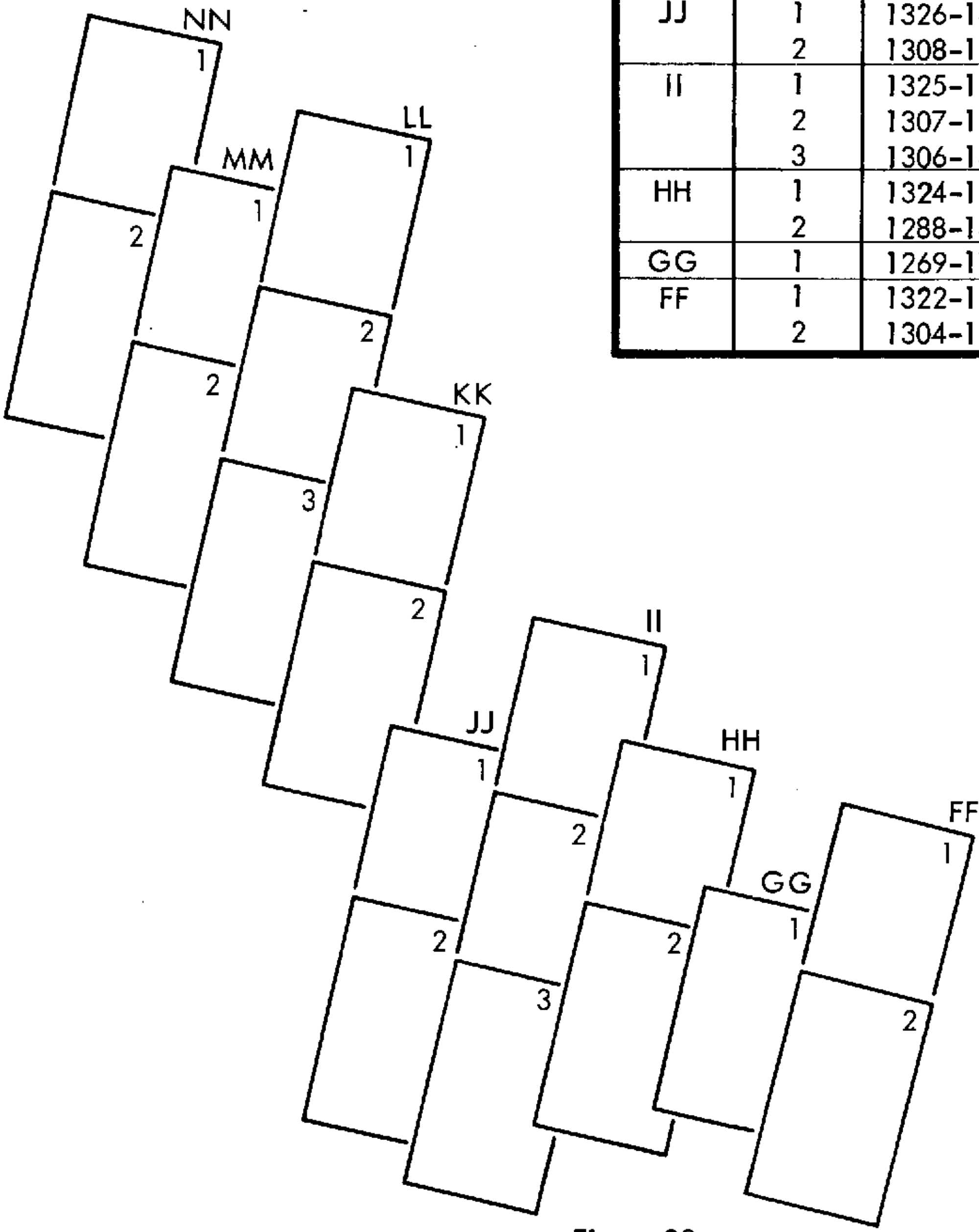


Figure 23

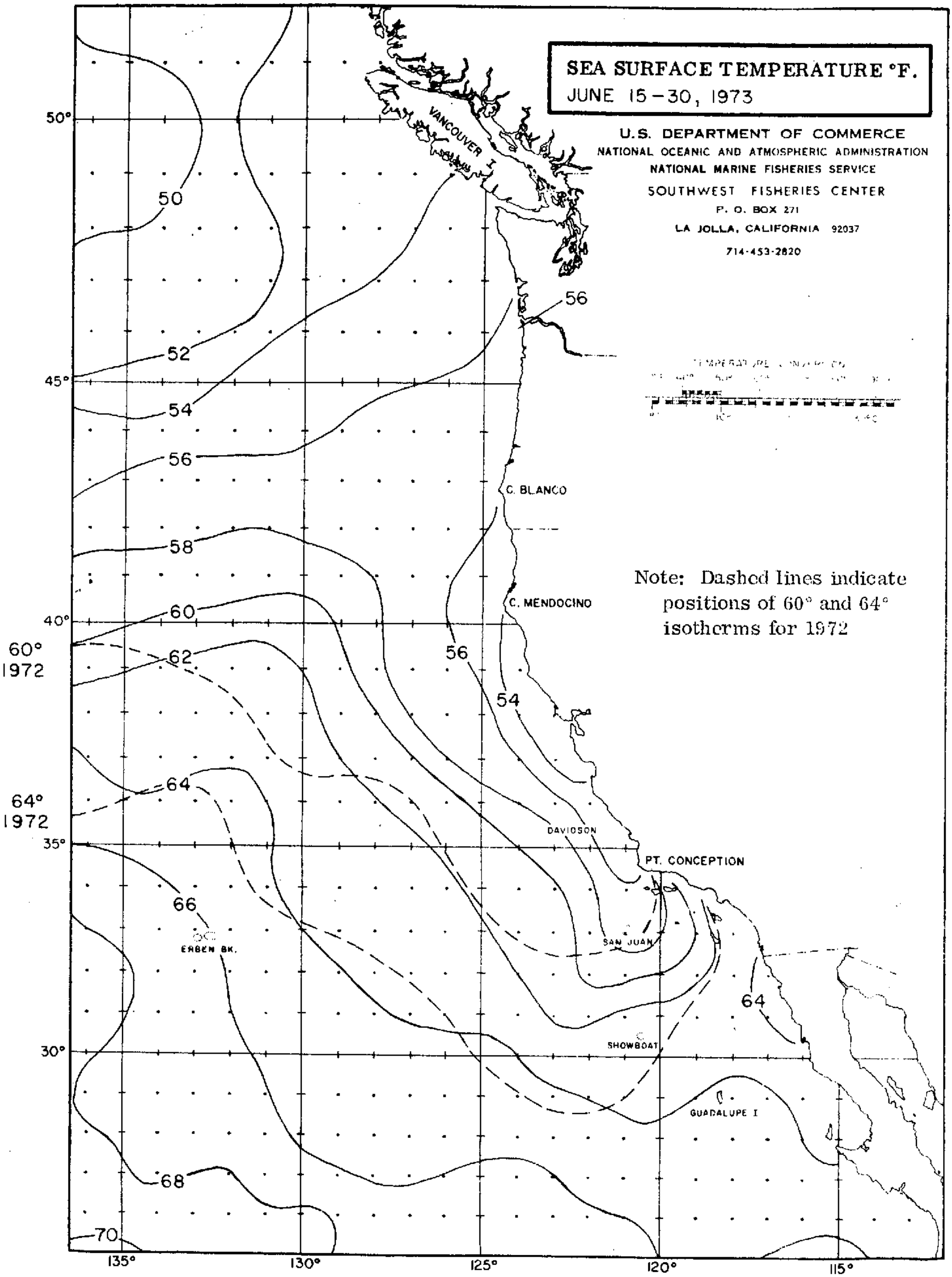


Figure 24. Transition Period Temperature Plot. Effect of California Current on Surface Nearshore Temperature is Shown. Note Cooler Upwelling off Northern California.

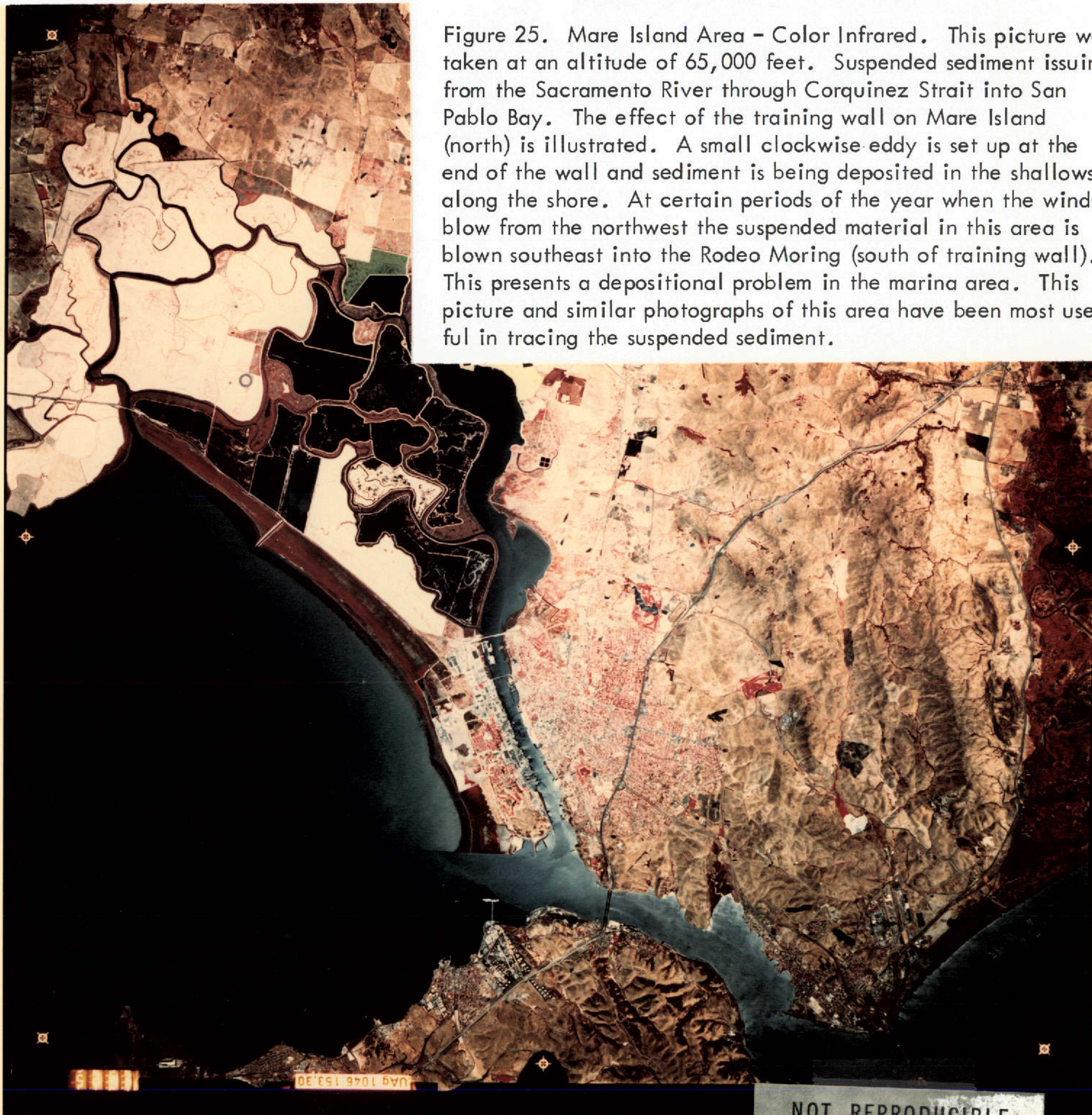


Figure 25. Mare Island Area - Color Infrared. This picture was taken at an altitude of 65,000 feet. Suspended sediment issuing from the Sacramento River through Corquinez Strait into San Pablo Bay. The effect of the training wall on Mare Island (north) is illustrated. A small clockwise eddy is set up at the end of the wall and sediment is being deposited in the shallows along the shore. At certain periods of the year when the winds blow from the northwest the suspended material in this area is blown southeast into the Rodeo Moring (south of training wall). This presents a depositional problem in the marina area. This picture and similar photographs of this area have been most useful in tracing the suspended sediment.

2.4 SUSPENDED SEDIMENT ANALYSIS

It has been estimated that 5 million tons of sand are dumped annually into the littoral transport of Southern California by rivers and ephemeral streams. Sand-budget studies imply no net loss of sand off the shelf due to longshore drift, wave swash drift, or coastal currents. At the same time, no significant retreat or buildup of the shoreline or the volume of coastal sand dunes is observed. Shepard and Emery proposed in 1941 that this equilibrium is maintained by the entrapment of sand in submarine canyons, with subsequent down canyon flows removing the sediment to deeper water. From major rivers (i.e., the Mississippi), Scruton and Moore showed in 1953 that a surface layer of fresh turbid water may extend up to 100 km offshore. Such a sediment plume is presumably composed of silt and clay-sized particles, and larger particles adsorbed to organic material. In Southern California such fresh water river plumes, according to Natland and Kuenen (1951) are restricted to less than a 2-km range offshore. Thus subsequent experimental studies have concentrated upon the elusive canyon turbidity flows and oscillatory down-slope movement of sediment in bottom turbid layers.

From this point of view, the extent of the visible sediment plume from the Southern California rivers, in flood, as revealed by ERTS-A is extraordinary. The sediment plumes continuous tonal values imply that they may be more significant for moving fine material beyond the "null point" line (15m depth contour) than has been heretofore supposed. They may in fact be partially responsible for maintaining the equilibrium. The attempted sediment load-film density correlation discussed in this report may provide a semi-quantitative method of evaluating this hypothesis.

A number of workers have noted that there is an apparent relationship between suspended sediment load and film density in aerial and space photos. Classical oceanographers have long used narrow band optical transmissometer data over a short path to infer sediment loads up to 1 or 10 mg/liter. Densitometric plotting of relative film densities is sufficient for temporal analysis of sediment level changes if an absolute exposure calibration is maintained on a day-to-day basis. Lacking this, relative sediment concentration estimates can be made within a given frame. In an orbital photo, due to its extreme scale, this is a significant contribution in that large dimensional current circulation and gross sediment transport can be discerned.

On a seasonal basis, stable sediment patterns are observed in ERTS-1 images to persist for several weeks with minor changes. In situ measurements of suspended sediment as a function of depth and lateral extent show these patterns to be extremely complex in three-dimensional development. Such sediment clouds with either a sharp or diffuse boundary at an intermediate depth above the bottom, will reflect or back scatter a disproportionate amount of light, thus confounding the film density/sediment load determination. Color of the sediment cloud may be used to identify it and assign an appropriate statistical weight in the image merging program, but the morphology of the turbidity cells is complex (e.g., see Figure 26 which shows typical color differences in a lagoon, surf zone, and deeper ocean waters).

Along the California coast, coastal mountain ranges cause surface winds to parallel the coast in an equator-ward direction, thus producing a dominantly offshore sweep for the sun-warmed surface waters. The colder subsurface waters rise to produce both thermal and suspended sediment-type gradients.

What is of concern here is to attempt a calibration of film density in terms of absolute sediment load. Color and turbidity are very much interrelated in that the particulates which cause water to be turbid themselves selectively absorb and scatter (when small enough) visible energy. Turbidity in water results from the presence of particulates, either organic or inorganic in nature, while color can sometimes be attributed to scattering and absorption by dissolved materials or by the water molecules themselves. A basic definition of turbidity is that it is a means of expressing that optical property of a sample which results in rapid attenuation of light by scattering and absorption by particulates. Although some investigators feel that the weight-concentration of suspended matter in the given optical path is infeasible to correlate with turbidity, the basic problem is illustrated in Figure 26 showing normalized transmittance of several turbid coastal and ocean water types. The strongest difference in transmittance is obviously due to the scatterer type (i.e., in the lagoon, in the surf zone, or ocean). A lesser effect (i.e., a few percent per meter) is due to the specific sediment load (e.g., reference curves M3 and M5 of Figure 26).

On the other hand, curves such as Figures 27 and 29 indicate that this may not be correct since it shows an excellent agreement. Indeed, logic tells one that the concentration of particulates in the path will be the dominating factor in a long path length. Size, shape, and refractive index are possibly not as important as once thought in terms of scattering. Hence, most oceanographers utilize suspended sediment concentration (organic plus inorganic) as a measure of turbidity. In situ measurements made with a 30 cm Secchi disk, in extremely turbid San Francisco Bay waters show strong correlation of sediment loads to the 4500 Å band film density readings.

The closest ERTS band analog is at 5000 Å. Apparently, the 5000 Å band indicates the position of the sediment cloud where the mean density change of the total suspended sediment in water is on the order of 10 milligrams/liter on a volumetric average over the water column.

In deeper water, a critical hypothesis to test is if the net increase in suspended sediment contributes dominantly to the backscattered light. In this case, higher reflectances due to multiple sediment layers at varying depths would be confounded with increased backscatter due to an increase in total suspended sediment.

Since a wide range of sediment samples and simultaneous aerial photography were available from an ONR Bathymetry Study for Portugese Bend and Inspiration Cove on Palos Verdes Peninsula near Los Angeles, they were chosen to test this hypothesis. These waters represent the "median" coastal seeing environment. Although in general, the Portugese Bend sediment load was observed to increase with water depth, both concave and convex gradients as well as linear increased with depth were characteristic of individual

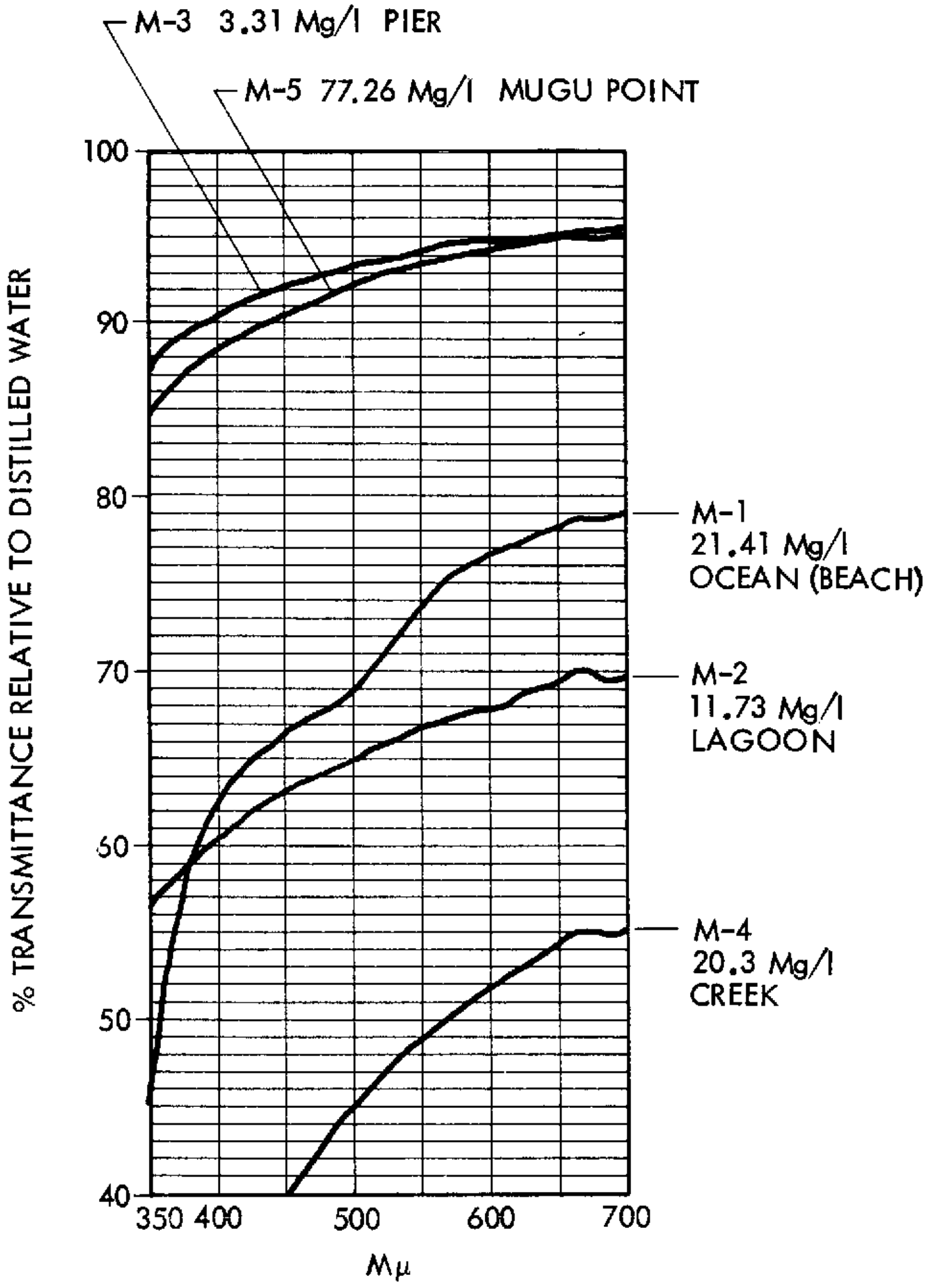


Figure 26. Mugu Lagoon & Ocean Water Sediment Loads and Spectral Transmittance

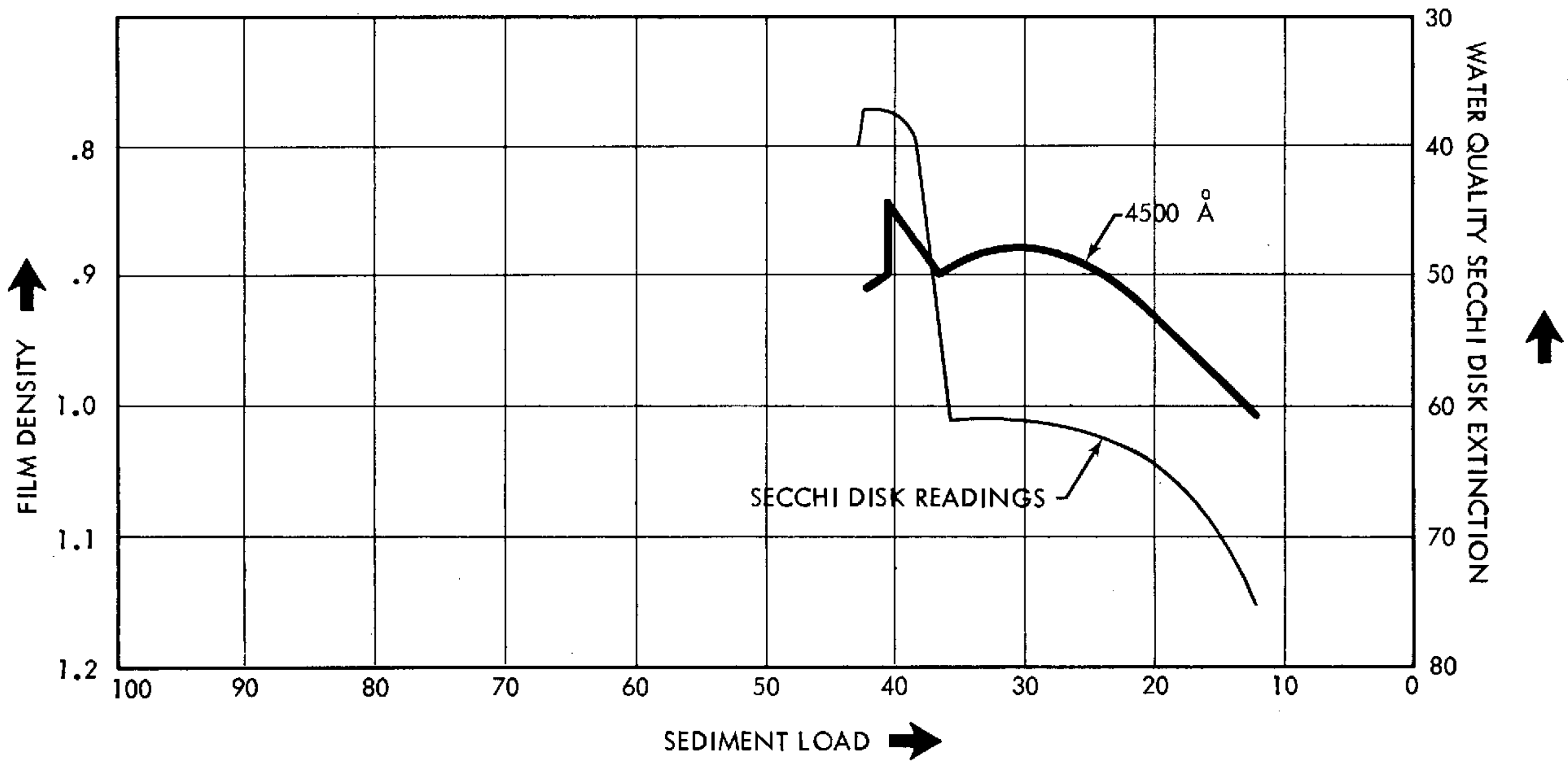


Figure 27 Film Density Vs. Sediment Load & Optical Extinction

stations in the raw sample data. These data ranged from a high of 44.9 mg/l to a low of 0.3 mg/l. It should also be noted that these particular data correspond to a period of runoff of terregenous sediment due to rain during the preceding week. Comparison of film isodensity traces over the sampled area with suspended sediment anomalies at depth showed neither a significant correlation nor anticorrelation. Hence, in the absence of a more extensive sampling grid, simple volumetric averages of sediment load were computed from the water sample analysis. (These ranged from 16 to 4 mg/l.) These showed a "break" at approximately the 20-foot depth contour corresponding roughly to a 10 mg/l decrease in sediment seaward. A visible scum line was also observed in the photography in this vicinity, evidently marking the boundary between these two water types.

These data were employed to derive the film density/sediment load calibration shown in Figure 28. The same calibration was applied to NASA frame 1108-18014-4, Figure 30A. Initially it was noted that the negative supplied by NASA did not have the stated densities on its stepwedge. Table 1 below provides the recalibration performed.

Table 1

Drakes Sediment Level		Step	1108-18014-4 Negative (Reference Figure 30) January 1969	
Station #	Mg/l		Density (Macbeth)	NASA
600	1.1	15	0.18	0.40
601	.56	14	0.40	1.31
602	2.51 (Avg)	13	0.62	1.48
603	3.6 (Avg)	12	0.76	1.75
604	15.3	11	0.86	1.87
		10	0.96	1.96
613	0.5	9	1.04	2.04
651	4.3	8	1.08	2.10
654	3.1	7	1.14	2.16
655	4.4	6	1.20	2.21

Comparison to the surface sediment sample measurements made by Drake (1972) is given in Table 1 above. Figure 30 gives the location of Drakes sample stations. These represent millipore filter residues for surface water samples collected in January 1969. Despite the time gap, these are seasonally comparable times and show a reasonable correlation. Note in particular Station 604 of Figure 30 which shows 15.3 mg/l in Drakes data versus 8-15 mg/l estimated from the ERTS frame (Figures 30 and 30A) and the sediment load film brightness relationship derived from airborne data (Figure 28).

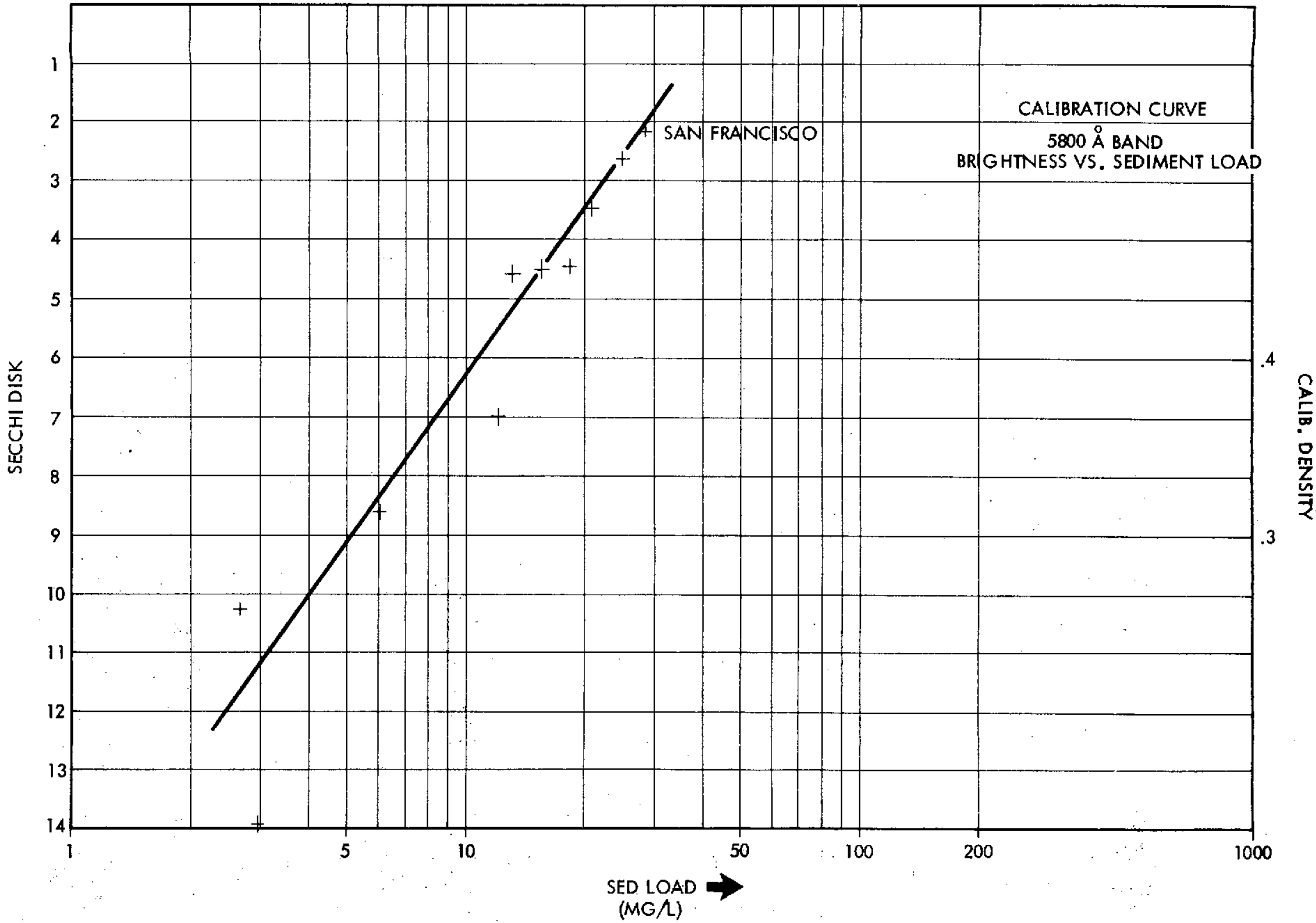


Figure 28. Calibration Curve for Sediment Load Vs. Film Density in Median California Coastal Waters (Film GAMMA = 1)

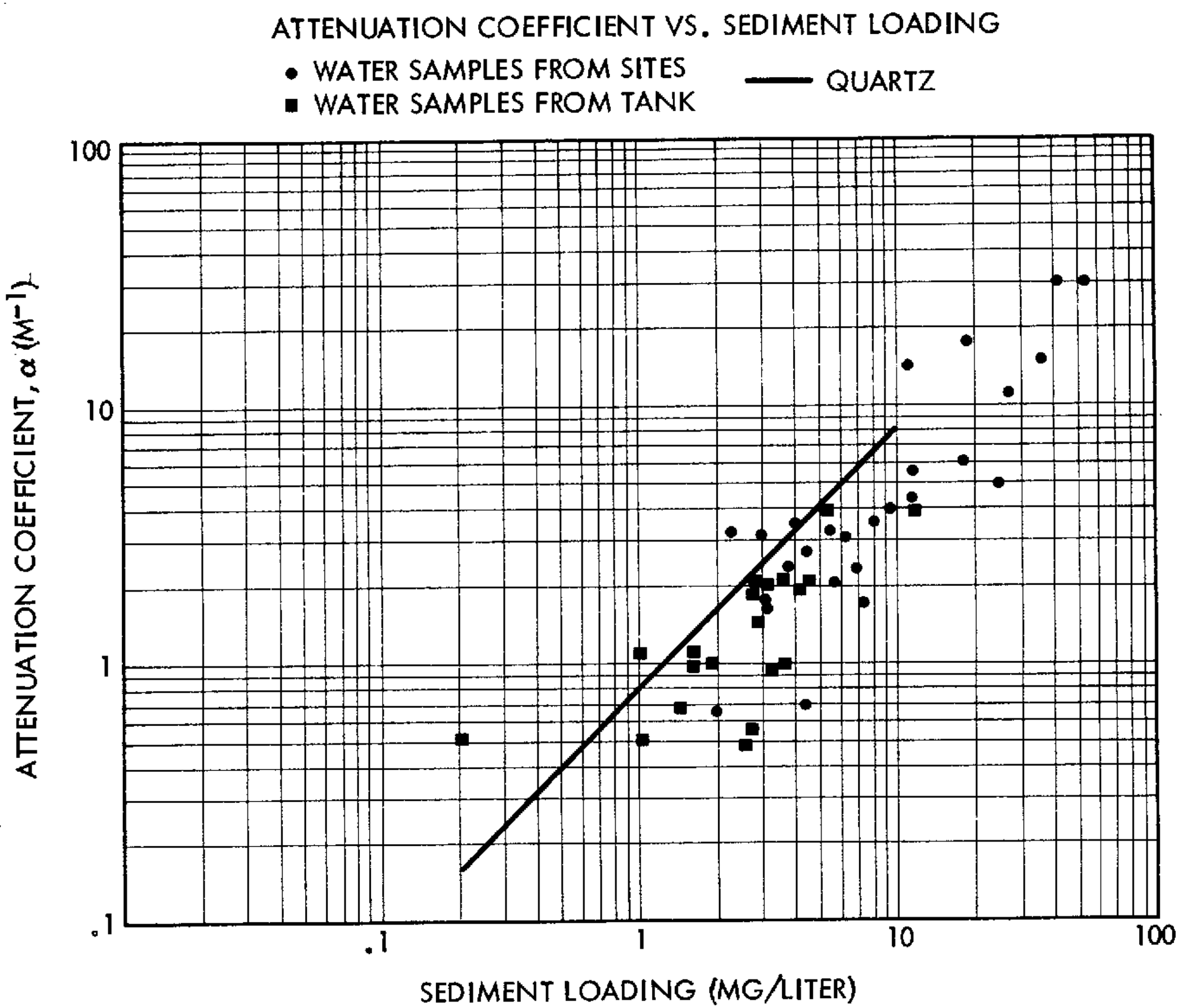
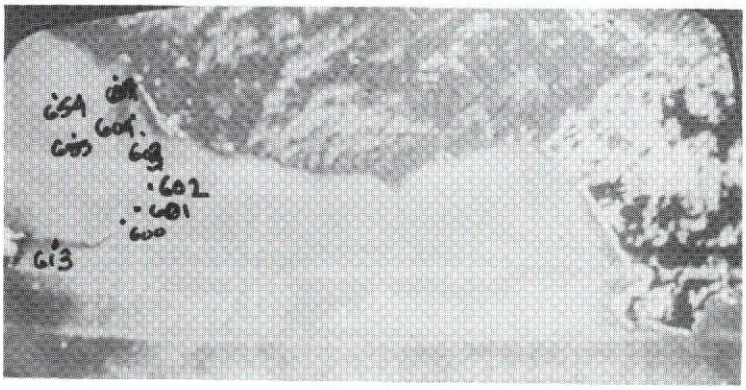


FIGURE 29. ATTENUATION OF BLUE-GREEN LIGHT VS. SEDIMENT LOADING
GHOVANLOU, ET AL 1973



(NASA ERTS Frame 1108-18014-4)
8 November 1972

Sediment Load
Key: (Interpolated from Figure 28)

Dark Blue	-	1-2 mg/liter	
Medium Blue	-	2-3 mg/liter	
Light Blue	-	3-4 mg/liter	
Light Green	-	4-8 mg/liter	insensitivity may be due
Dark Green	-	8-15 mg/liter	to reciprocity failures.
	-		

Figure 30. Tentative Mapping of Near-Surface Suspended Sediment from ERTS Imagery

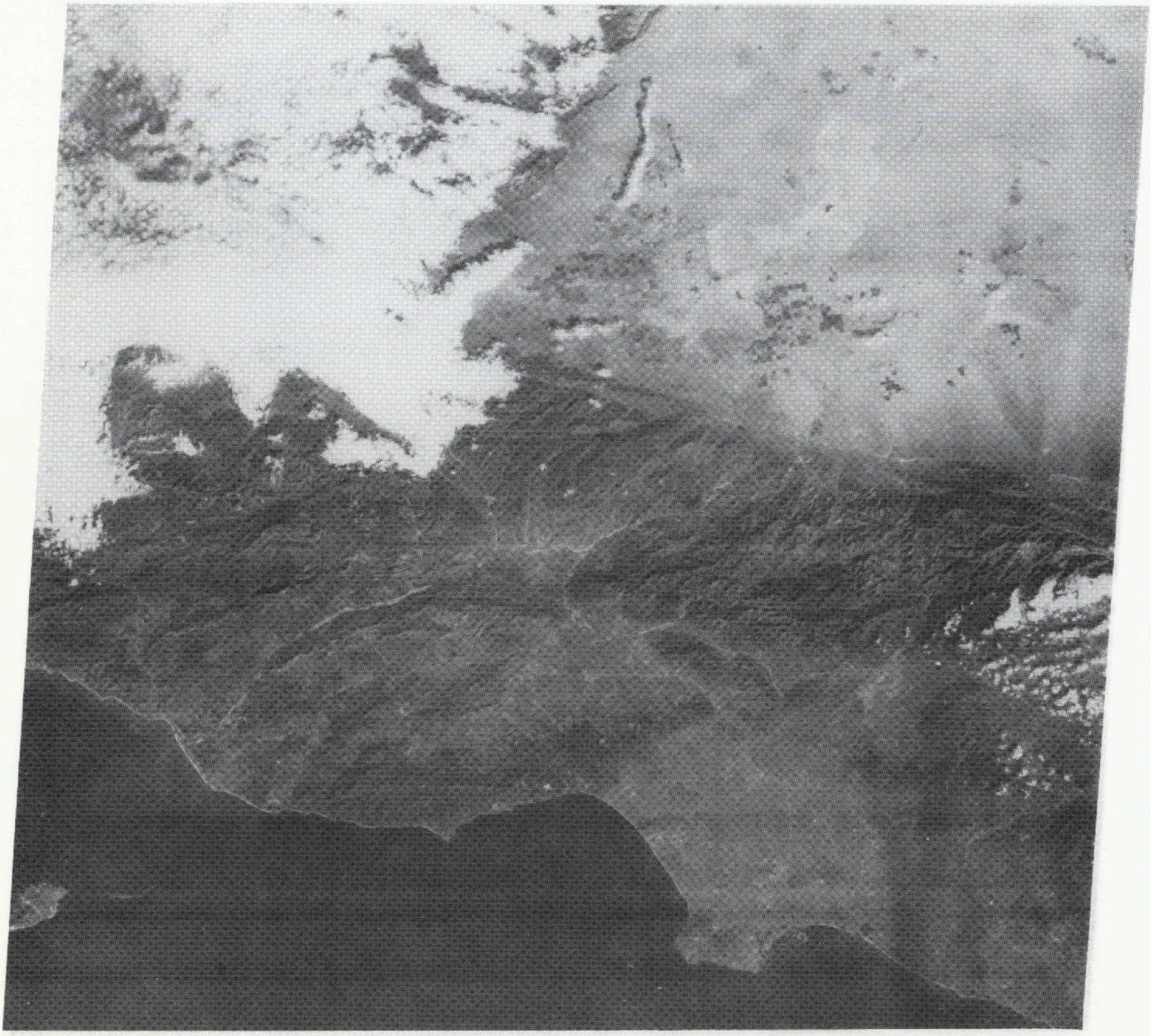


Figure 30A Original ERTS Frame 1108-18014-4

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2.5 FLYING SPOT SCANNER ENHANCEMENTS (FSS)

Imagery, enhanced and improved for nearshore sediment detection and delineation, has been recorded on film from NASA computer compatible tapes (CCT). Rockwell's modified flying spot scanner (FSS) system is used to convert NASA digital data to hard copy film. This film writing/reading system uses a high resoultion CRT as a light source for data processing. A spot size of 0.7 mils can be achieved when normal brightness and signal levels are employed.

Data on a 9-track 800 BPI tape is directly applied to the system at a real time rate. Recorder playback clocks are used to discretely position the CRT spot through one of five fixed digital rasters.

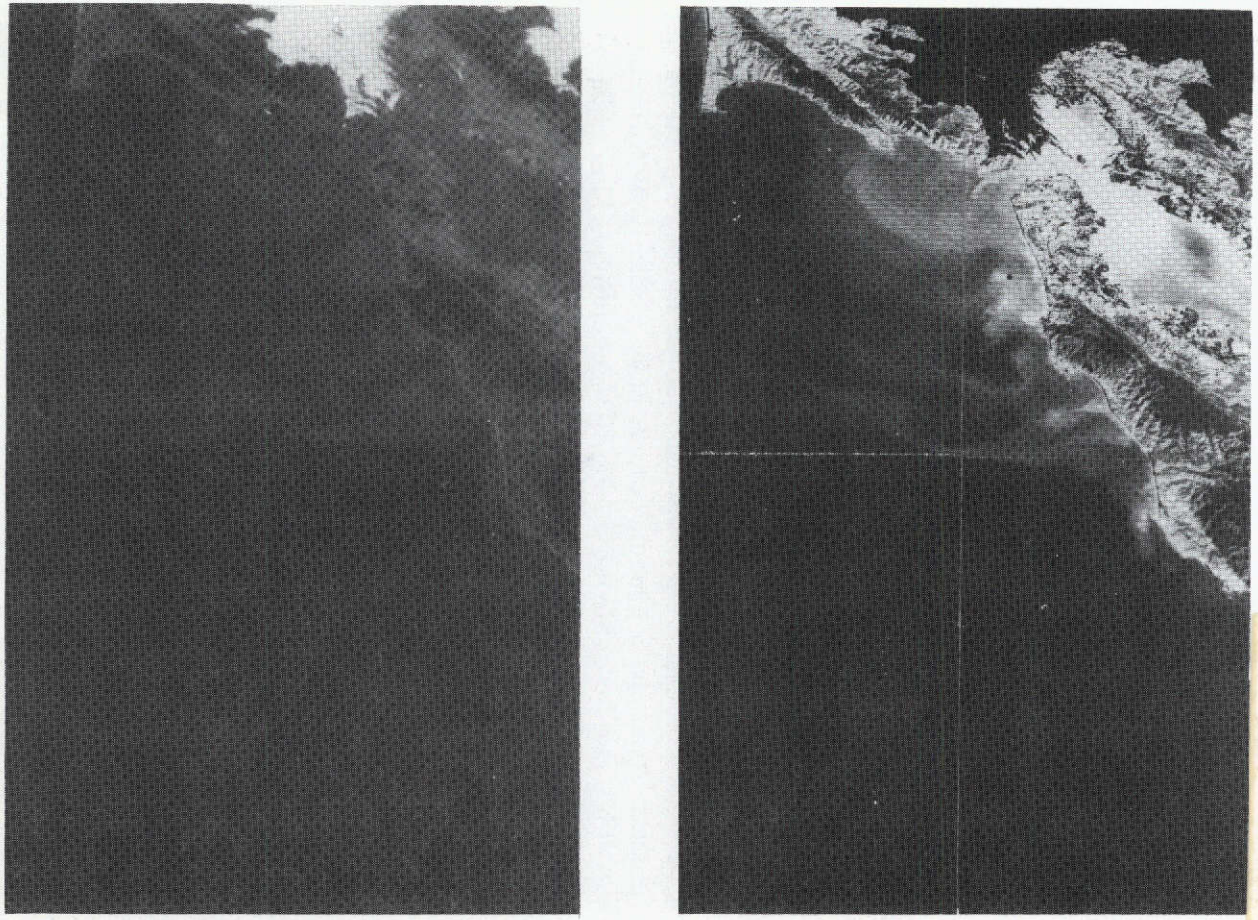
Horizontal and vertical deflection is provided from two 12-bit digital to analogy converter (DAC's). The Z-axis modulation of the CRT's intensity is performed after digital to analog conversion of the video. Video gain and level manipulation are controlled through a wide bandwidth video amplification stage to provide signal levels yielding optimum film gamma for every scene.

Enhancement Technique

NASA Original Bulk Imagery displays the scene's dynamic range within the films available gamma range. Typically, however, the sediment features which are of particular interest on this nearshore processes study are represented in only a small portion of this gamma or density range. Thus, the sediment features have a relatively low contrast as compared with that which can be achieved during film recording. Figures 31 and 32 portray a typical example of how the contrast of sediment features can be enhanced. Parts (a) of the two figures are direct prints from MSS band 4 and 5 negatives. The scenes display a nominal contrast with white or light clouds in the northeast corner and a dark density or black in the ocean regions. These prints were exposed on poly contrast Kodak paper with a No. 3 filter to increase the contrast of offshore sediment features.

The (b) parts of the two figures are prints from the negatives recorded on the FSS using the analog preprocessing technique. A comparison between the two matching images immediately illustrates the advantages of controlled playback exposures. NASA imagery must be recorded on film in such a way that all signal levels are within the film's density range. It would not be practical or desirable for NASA to generate negatives with exposures optimized for only selected portions of any scene's signal range. However, for special features of interest, such as offshore suspended sediment, its signal range is limited and relatively small.

This small signal range can be amplified prior to recording as demonstrated here so that maximum contrast between sediment features can be realized. To contrast enhance features within any scene, two signal processing techniques are available in the FSS system. One method employs standard analog amplification methods (Analog



(a)
1130-18235-4 ORIGINAL

(b)
1130-18235-4 FSS

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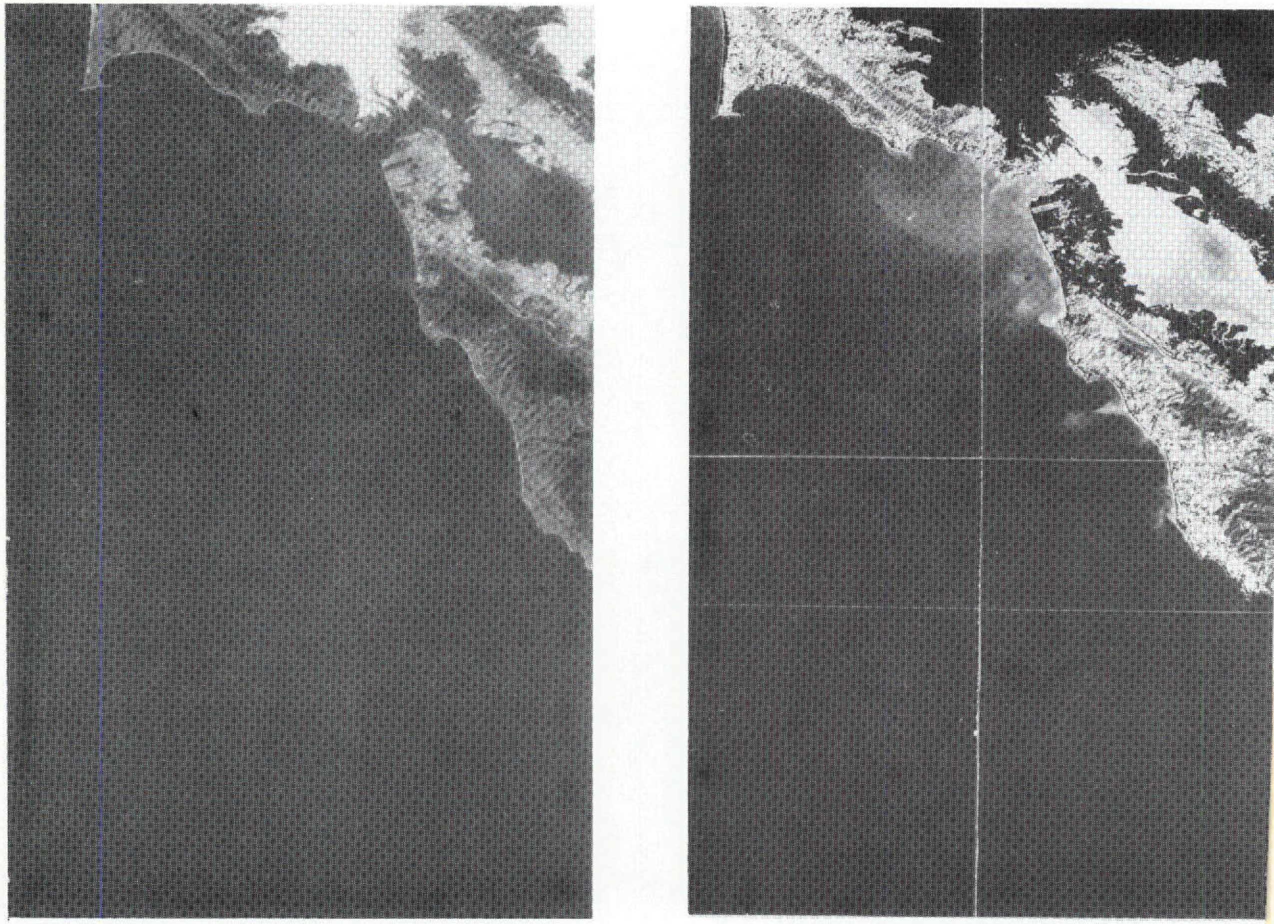
Figure 31. San Francisco FSS Enhancement
Scene 1130-18235-4

Note gyre in the Gulf of the Farallones and offshore sediment movement south of Half Moon Bay (in b).



(a) (b)

1130-18235-5 ORG 1130-18235-5 FSS

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Figure 32. San Francisco FSS Enhancement
Scene 1130-18235-5

Surface sediment distribution is shown. Gyre and offshore movement near Devils Slide and Half Moon Bay are emphasized (in b).

Preprocessing Technique) to control the signals gain and DC level setting. The alternate method is a hybrid digital/analog technique. In this method the eight-bit parallel digital data is shifted at the input to the digital to analog converter (D/A) to achieve the appropriate gain. By this second method, discrete steps in gain of 2/1 can be applied to the input signals. The D/A output is then fed through a unit gain analog amplifier where DC offset is controlled. In the application of either of these techniques for enhancing ERTS scenes, particular problems may present themselves. Thus, a more detailed discussion of these techniques in a total system context is presented below.

1. Analog Preprocessing Technique

The exposure of the FSS negatives is a function of numerous parameters and systems settings (CRT voltage or brightness, signal levels, scan rate and raster size, lens aperture, and film characteristics, etc.). To reduce the effect and randomness of these variables, an analysis of FSS system performance was undertaken as they applied to ERTS data reduction. The results of this study are presented in a following section. However, it is necessary to understand at this point that all parameters and settings have been standardized or fixed for the ERTS data task. This approach of formulating a standard system configuration and data reduction procedure was necessary so that consistent optimum high quality products can be produced. Additionally, the processing time has been reduced to a minimum. All other parameters being fixed, the film exposure is now only a function of the signal levels present at a system monitoring point. This point is in the video chain at the output of the analog video preprocessing amplifier prior to being input to the electron beam video drive amplifier. A signal swing from 0 to 0.5 V will result in a log film density of 0.41 to 2.25.

The digital data from the tape deck is converted to analog signals for preprocessing prior to film recording. The video amplifiers are used used to control the signal gain and DC level so that the signal levels are within the 0 to 0.5 volt range. For a normal exposure, the total signal range of any scene is adjusted so that it is within this voltage window. To enhance the contrast of sediment features, the signal levels are increased by virtue of the analog gain controls so that the video signals representing sediment features swing from 0 to 0.5 V. As noted above, the application of this analog gain to enhance features presents an additional problem. This problem is that signals from other features, such as land, beach, etc., have also been amplified. These signal levels are larger than the maximum desirable signal level of 0.5 V. Recording of this amplified full dynamic range signals would result in poor imagery, as well as presenting potential damage to the CRT. The large signal levels present two problems. Firstly, these larger signals could saturate the post amplification stages of the video amplifiers, thus causing holdover of the video

signals in regions of land-water interfaces. Secondly, and more important, the excessive signal level will overdrive the CRT brightness. This would result in an increased CRT spot size, internal light scattering, and thus a fogging in the imagery. To eliminate these problems a signal limiter has been incorporated into the video chain. Gain can be applied to the video signal, but the output signal range is fixed to 0 to 0.5 V. This gain, applied to the raw video, results in contrast enhanced sediment feature in the final film negatives. The amount of enhancement is a function of the gain applied. Figures 31 and 32 reveal the results.

2. Hybrid Digital/Analog Technique

   The second preprocessing technique available for contrast enhancement employs all the capabilities and system settings as described in the analog discussion. The single exception is digital gain. It must be remembered that to perfrom contrast enhancement, one must control signal levels, and this must be done within system constraints, thus, the limiter function. In the analog case, the gain is continuously controllable from 0 to 100. Thus, it is difficult to repeat amplifier settings, or to specify differences between settings. This is not to say that the system cannot be calibrated to get such information. However, additional steps are required. The digital techniques allow us to apply gain in discrete multiples of two. This technique then yields the same results, signal gain, but in known multiples. The procedure is simple and straightforward assuming a basic knowledge of digital to analog converters.

The two techniques described above are those used to control signal gains. Other techniques are available for application to the analog signal. These include non-linear amplification, thresholding, and differentiation. Each technique yields an enhanced image; however, for sediment detection and delineation, contrast enhancement yields the optimum results.

FSS Modification and Improvement

The analysis referred to in the above text has improved the data product as recorded on the FSS system. Extensive analyses was directed toward isolating problem areas in the FSS system which in the past prevented producing imagery displaying resolution that improved on prints from NASA original negatives. In the past, the FSS system has been used to generate imagery with enhanced sediment features (e.g., gain control was used to increase the contrast of the sediment anomalies).

This analysis resulted in isolating three major problem areas: (1) CRT dynamic focus, (2) the recording lens, and (3) the recording film. The dynamic focus power supply was readjusted so that the CRT spot remains focused at all points on the CRT face. Additional

shaping circuits were incorporated and a complete adjustment made to yield an optimum dynamic waveform. Secondly, a new recording lens was installed into the system. The result was an increase in the modulation transfer function of the optics and a sharp image plane. Care was taken during installation to achieve a critical focus in the image plane. The third problem area was the film used for recording. Additionally, the recording procedure was standardized ro reduce the time required to playback an image. Candidate films were reviewed based on their characteristic curves, granularity, and spectral sensitivity. Additionally, a requirement for red light insensitivity to make handling easier was imposed. The film picked was Kodak TRI-X Ortho type 4163*. Test exposure and processing times were tried to determine a standardized procedure. This resulted in a relationship between input voltage levels and film densities. The following table shows this relationship:

Input Voltage Level	Log Film Density
0	0.41
0.1	1.03
0.2	1.50
0.3	1.93
0.4	2.15
0.5	2.23

*Processed in D-19 at 68 F° for 7 minutes.

Data from CCT of frame 1183-18105-4 was used during the first test runs. These runs showed another problem. If the signal levels of interest are between signal levels, both above and below their levels, the signals larger than those of interest become too large as gain was applied to the signal. These signal levels actually become large enough to damage the CRT phosphor or the light level increase to a point which results in fogging of adjacent data. To remedy this problem, a signal limiter was incorporated into the video section of the FSS. This is displayed on the imagery as a fold-over condition as illustrated by the black clouds in Figures 31-b and 32-b. As the signals level increases to this safety threshold, the film image is increasing in density. Once the signal increased past this level, the resulting density is folded over to clear and remains there until the signal level falls below the safety threshold level.

The incorporation of the above modifications and procedures resulted in improved FSS imagery. The new imagery displays resolution comparable to NASA originals. Thus, enhanced data can be recorded with little reduction in resolution. Figures 33 through 37 are examples of Analog Preprocessing Technique enhancements.

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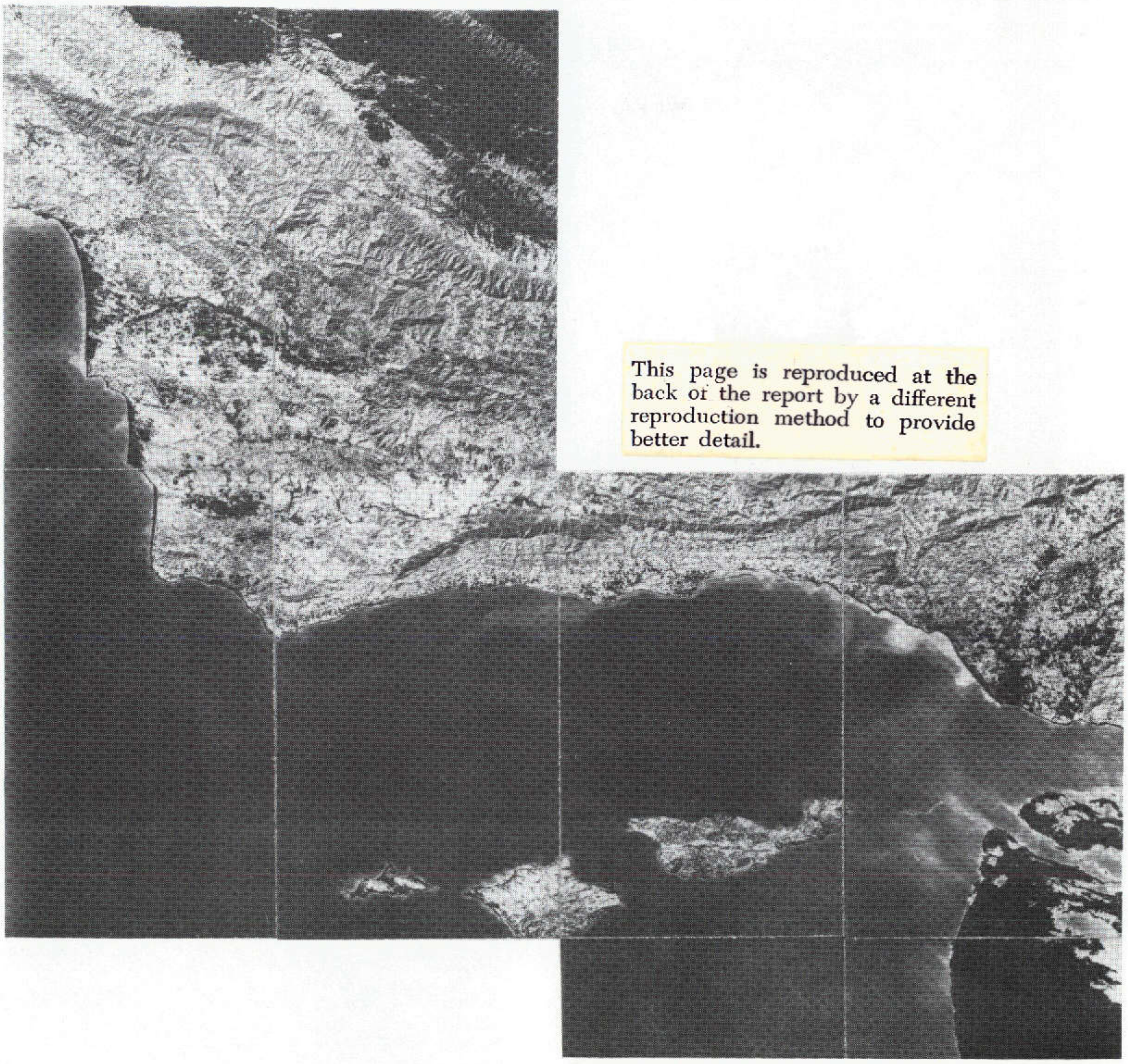

Figure 33. Santa Barbara Channel FSS Enhancement - Hi-Gain

Scene 1127-18035-4. This enhancement shows the details of nearshore sediment transport including the movement of material from the Santa Clara River toward Santa Cruz Island, November 27, 1972.

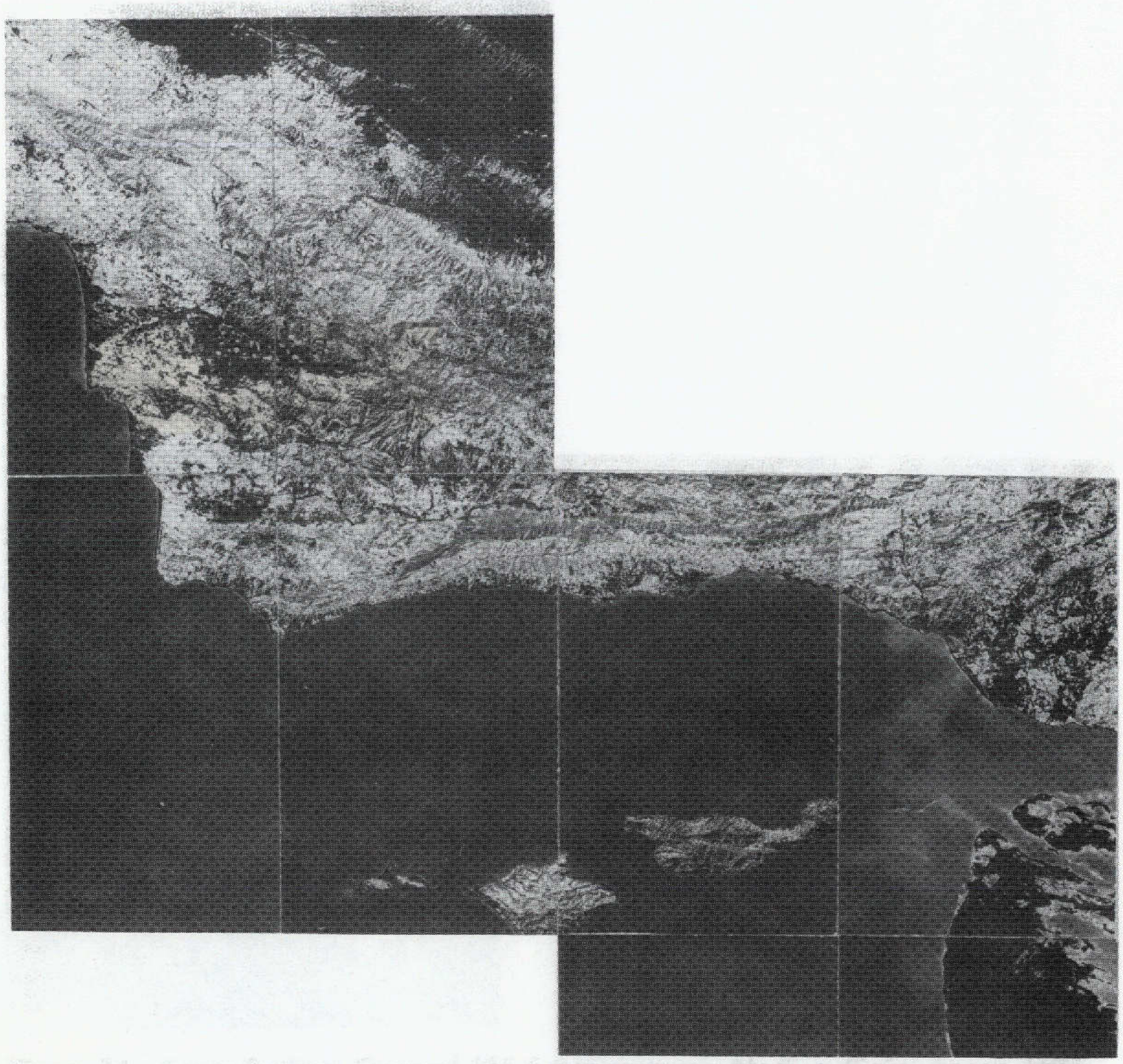

Figure 34. Santa Barbara Channel FSS Enhancement - Medium Gain, Scene 1127 Medium Gain, Scene 1127-18073-5

Same enhancement as Figure 33 but gain setting is medium. Less detail is illustrated in nearshore area but offshore near Anacapa Island detailed definition of suspensates is observed. November 27, 1972.

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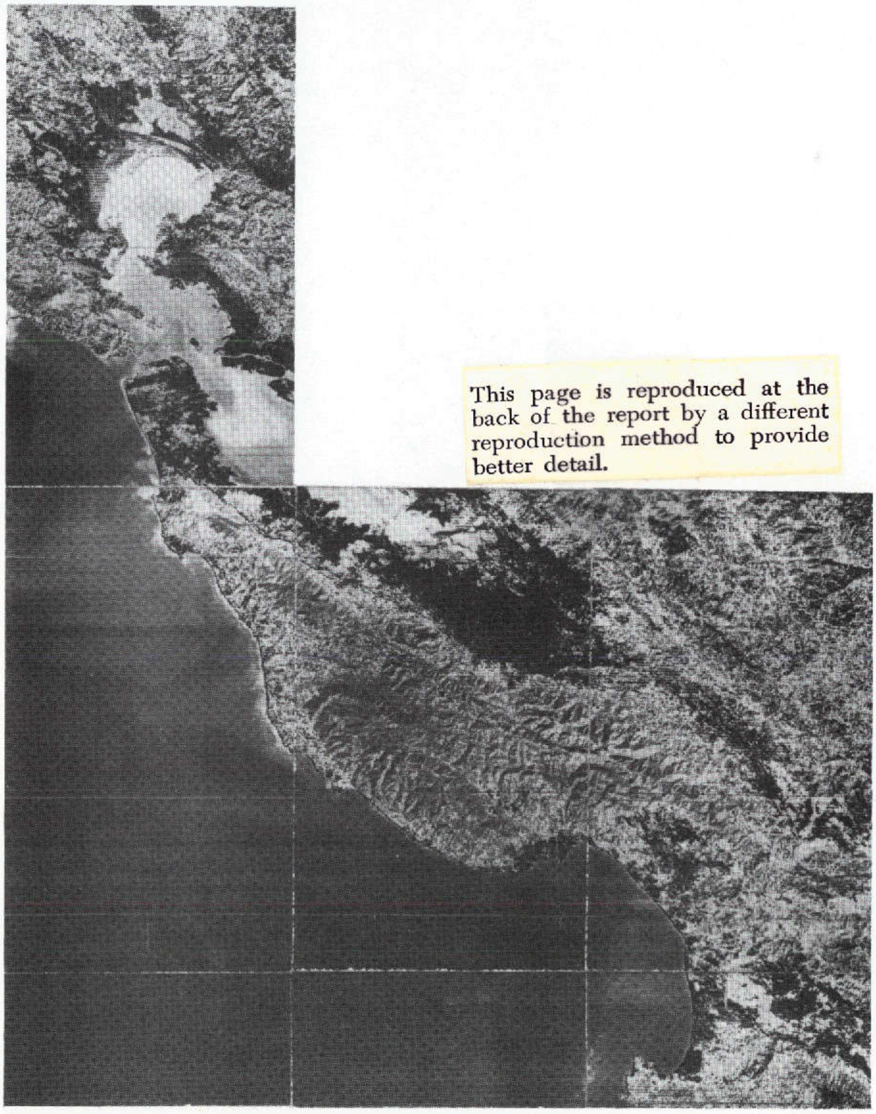

Figure 35. San Francisco – Monterey Bay FSS Enhancement
Medium Gain, Scene 1165-18175-5

Nearshore sediment near the Devils Slide and Pigeon Point are emphasized. January 4, 1973

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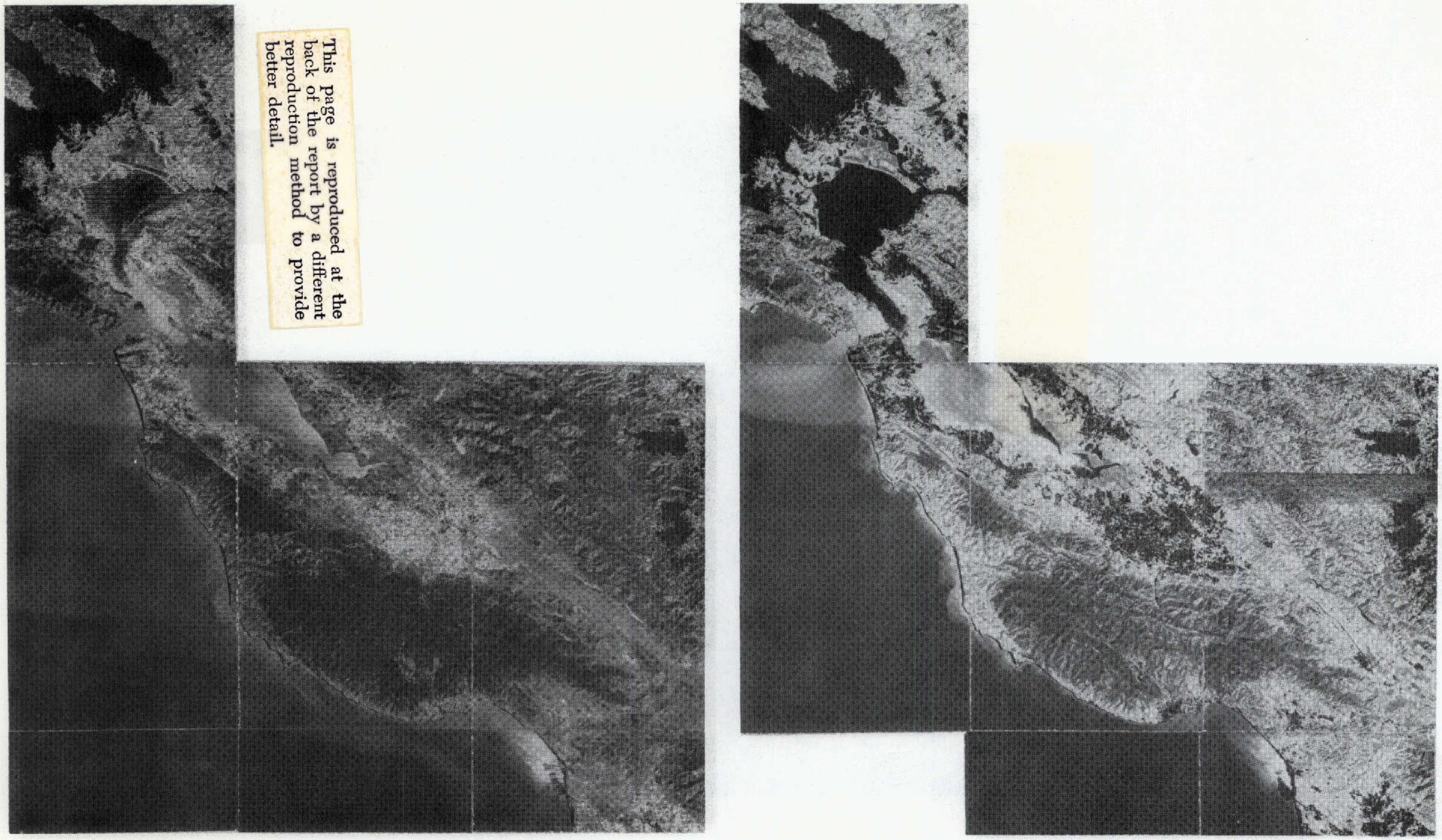

Figure 36. San Francisco - Monterey Bay FSS Enhancement Scene 1183-18175-4 and -5

A comparison of a medium gain FSS enhancement of channels 4 (left) and 5 (right) is shown. Note material issuing from San Francisco Bay and the Salinas River in Monterey Bay. January 22, 1973.

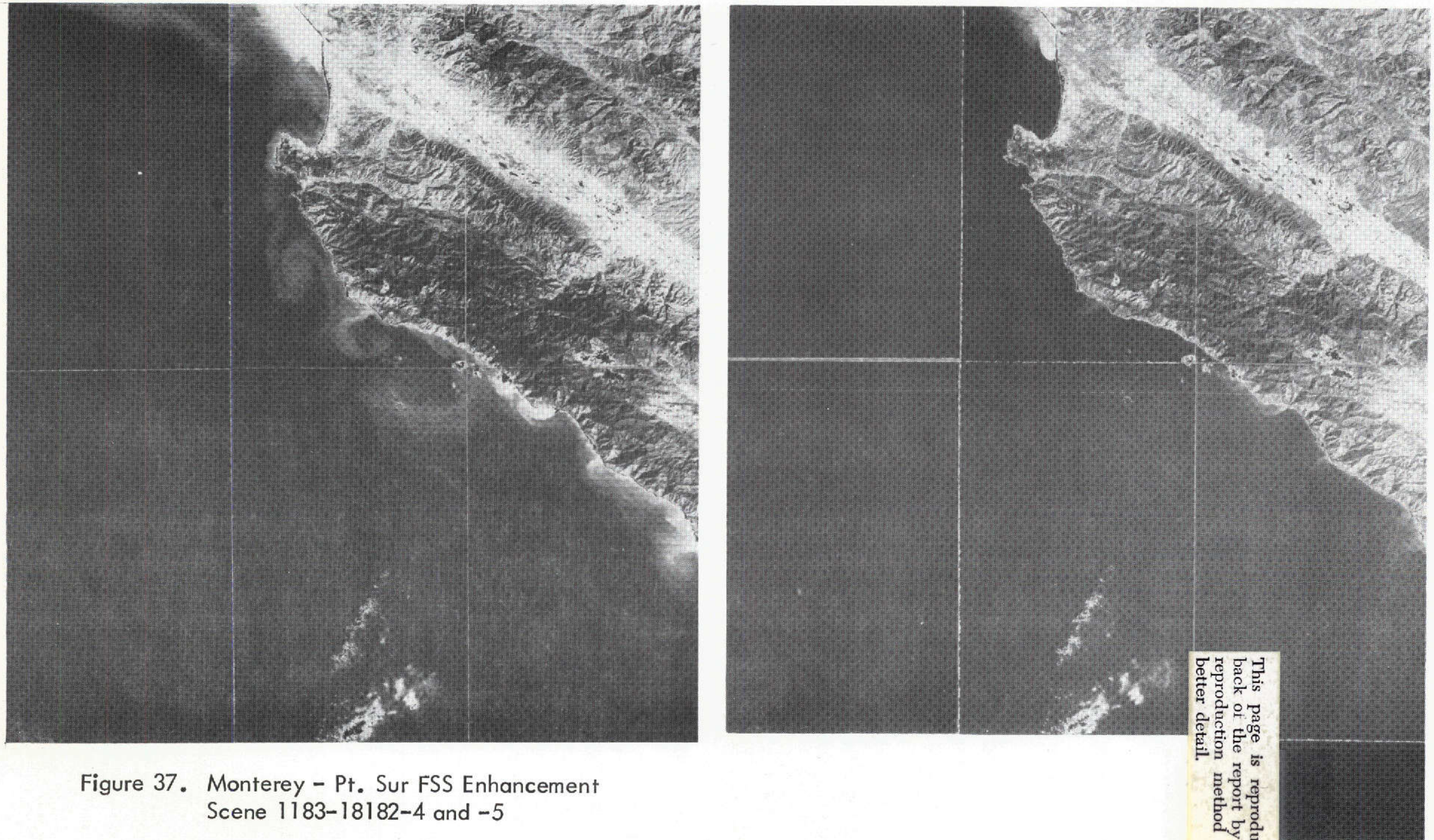

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Figure 37. Monterey – Pt. Sur FSS Enhancement
Scene 1183-18182-4 and -5

Channel 4 (left) and 5 (right) were enhanced using the FSS medium gain mode. Several opposing gyres are present south of the Monterey Peninsula. January 22, 1973.

2.6 COMPUTER PROCESSING OF CCT

Digital processing activity during this 6-month reporting period consisted of two major efforts: (1) develop the software and techniques to convert bulk CCT's to formats compatible with Rockwell's existing hardware and software systems, and (2) develop the software to interface ERTS digital tapes with Rockwell's contouring programs to generate radiance contour maps for use in determining near surface suspended sediment in the California nearshore areas of interest. The primary objective of this processing is to provide a means for analyzing coastal sediment distribution. The reformatted data was used in flying spot scanner enhancements as described in Section 2.5.

BULK CCT PROCESSING

MSS bulk CCT's provided by NASA are organized into groups of tapes which depict a scene approximately 100 nautical miles (nm) square. There are four tapes each scene containing multispectral information on one strip 25 nm wide.

The software programs developed convert these bulk CCT's to a flying spot scanner (FSS) compatible tape produced for each spectral band. To achieve this compatibility certain conventions were adopted as illustrated in Figure 38 and described below.

The FSS line format requires that input data be organized in lines of lengths of 256, 512, 1024, 2048, 4096 points (bytes) each. A 25 nm strip from bulk tape consists of lines with 870 points (bytes) each. The 1024 byte line length required by the FSS was achieved by adding to the data dummy bytes at the end of each line.

Similarly, the standard number of lines selected for scenes to be reproduced on the FSS was fixed at 1024. Since each 25 nm strip is 2340 lines, the adopted convention results in three blocks of data per spectral band for each strip. The last block actually consists of only 292 data lines, the remaining 732 lines are dummy data lines inserted during processing.

Figure 39 is a photograph of a 25 nm strip reproduced and enhanced on the FSS from bulk CCT data (note the block sizes). This is a direct reproduction of the bulk CCT data and has not been corrected to any degree. Future software developments will include the incorporation of de-skewing options to the FSS compatible tape generation programs. The overlay shown depicts the area selected for subsequent processings. This figure and all others showing CCT data were generated using spectral band 4 tapes since they have been previously identified as having the best reflectance characteristics for identifying suspended sediment in ocean waters.

CONTOURING PROGRAMS

The contouring programs were used to generate plots of reflectance contours around the Monterey Peninsula, the Santa Barbara Channel and the south San Francisco coastal area, as shown in Figures 39 through 44. Lines depicting the shoreline are superimposed

on each figure. First, the raw data contained in the bulk tapes is analyzed on a point by point basis to determine its micro-characteristics. Figure 45 is a computer dump of the data which represents the California coast around the Monterey Peninsula. Each number corresponds to a pixel and the specific value is representative of the reflectivity recorded for that point. Due to the scattering effect caused by small reflectivity variations, a smoothing operation is performed on the data before the contour maps are generated. The process for generating these contours is illustrated in Figure 46. Briefly, this contouring process requires the following steps.

1. Spectral Channel Selection - A specific rectangular area within the 1024 x 1024 scene can be selected during the sampling process. The contouring program is sized to accept a maximum of 4900 data points.

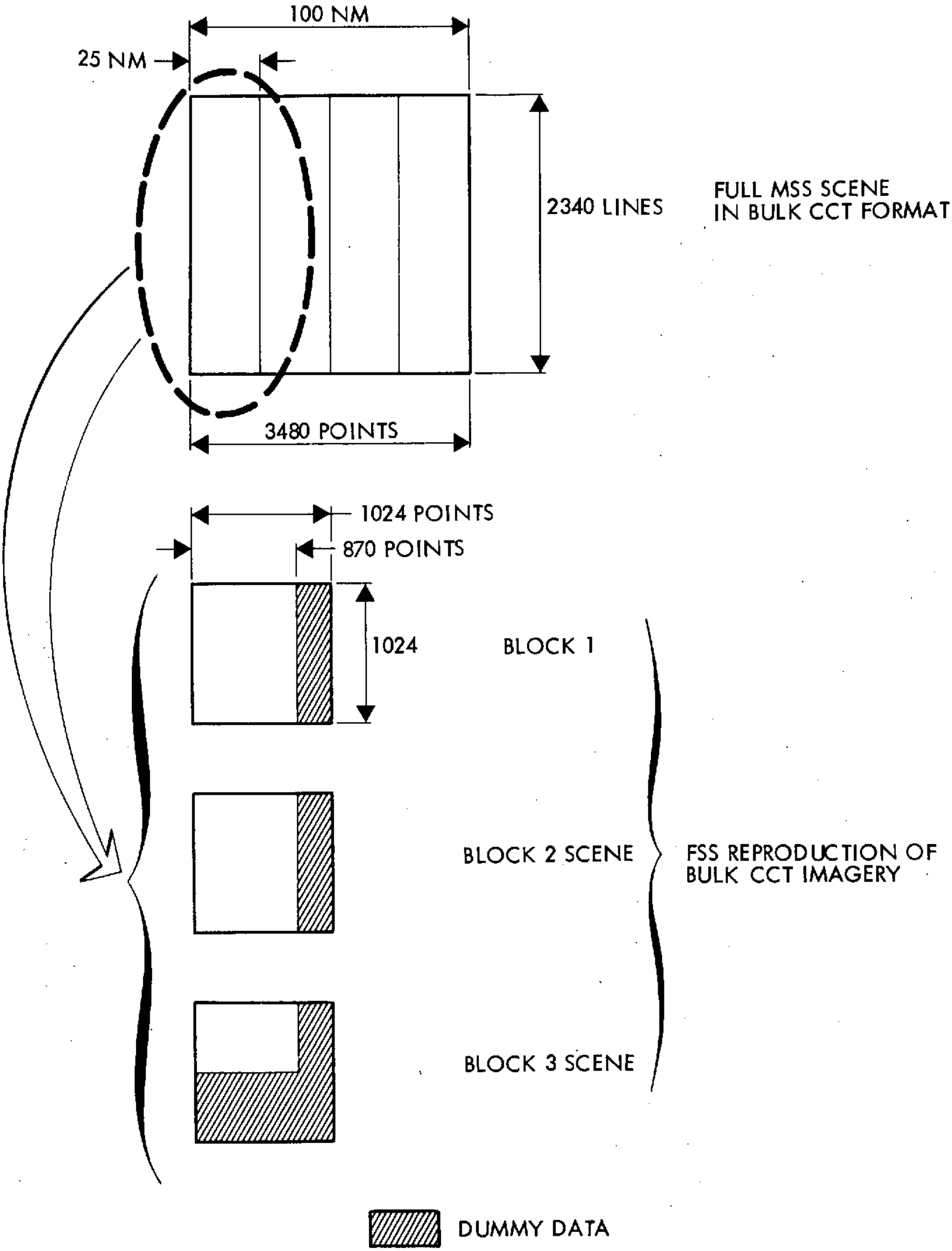
2. Area Size Selection - By appropriately designating the sampling rate, areas of various sizes can be selected for contouring. For example, a 1024 x 1024 block represents a 25 x 25 nm area. Therefore, a square array of data points (64 points long on each side 64 x 64 = 4096) can represent the full scene (25 nm x 25 nm) 1/4 th (12.5 nm x 12.5 nm), 1/8 th (6.2 nm x 6.2 nm), 1/16 th (3.1 nm x 3.1 nm) or 1/32 nd (1.5 nm x 1.5 nm) depending on whether a sampling rate of 16, 8, 4, 2, or 1 is selected. For the present application, a sampling rate of 8 was found to yield the most satisfactory results. This allows contouring in 6.2 nm x 6.2 nm geographical blocks as illustrated in Figures 40, 42 and 44.

3. Digital Dump Selection - The data points representing the area selected are punched on data cards and may also be dumped on the line printer for verification.

4. Data Smoothing - Once a specific data block has been selected, a smoothing program is used to operate on the data. This involves using multiple regression surface fitting technique that eliminates scattering in the data values. This approach yields a set of data values which when contoured will reflect large area sedimentation patterns rather than localized variations.

5. Annotation Selection - During the contouring and annotation process, several formatting parameters can be specified: (a) a grid is superimposed on the contours and may be located to represent latitude and longitude lines; (b) the ratio of physical distance covered by equal numbers of points in the X and Y directions may be specified; this is useful in working with bulk data since 100 nm in the X direction is represented by 3480 points while only 2340 points represent 100 nm in the Y direction. This distortion may be corrected in the contoured plot by simply specifying this ratio.

A step external to the above process was incorporated in the generation of the contours shown in Figures 40 and 44. This consisted of using spectral band 7 as a reference to generate the shoreline. The characteristics of this band are such that the reflectance levels of land features are significantly lower in value than reflectance levels of water features (typically, water reflectivity value range is 0 to 3 and land reflectivity values range from 11 to 15), therefore the shoreline can be easily discerned. A digital printout of band 7 was used to locate the shoreline on a similar printout of the identical area in band 4. The land mass was then masked and assigned a large reflectance value that would produce a distinct contour in the final output.



100 NM
25 NM
2340 LINES
FULL MSS SCENE
IN BULK CCT FORMAT
3480 POINTS
1024 POINTS
870 POINTS
1024
BLOCK 1
BLOCK 2 SCENE
BLOCK 3 SCENE
FSS REPRODUCTION OF
BULK CCT IMAGERY
DUMMY DATA

Figure 38

AREA OF SOUTH
MONTEREY
PENINSULA
CONTOUR MAP

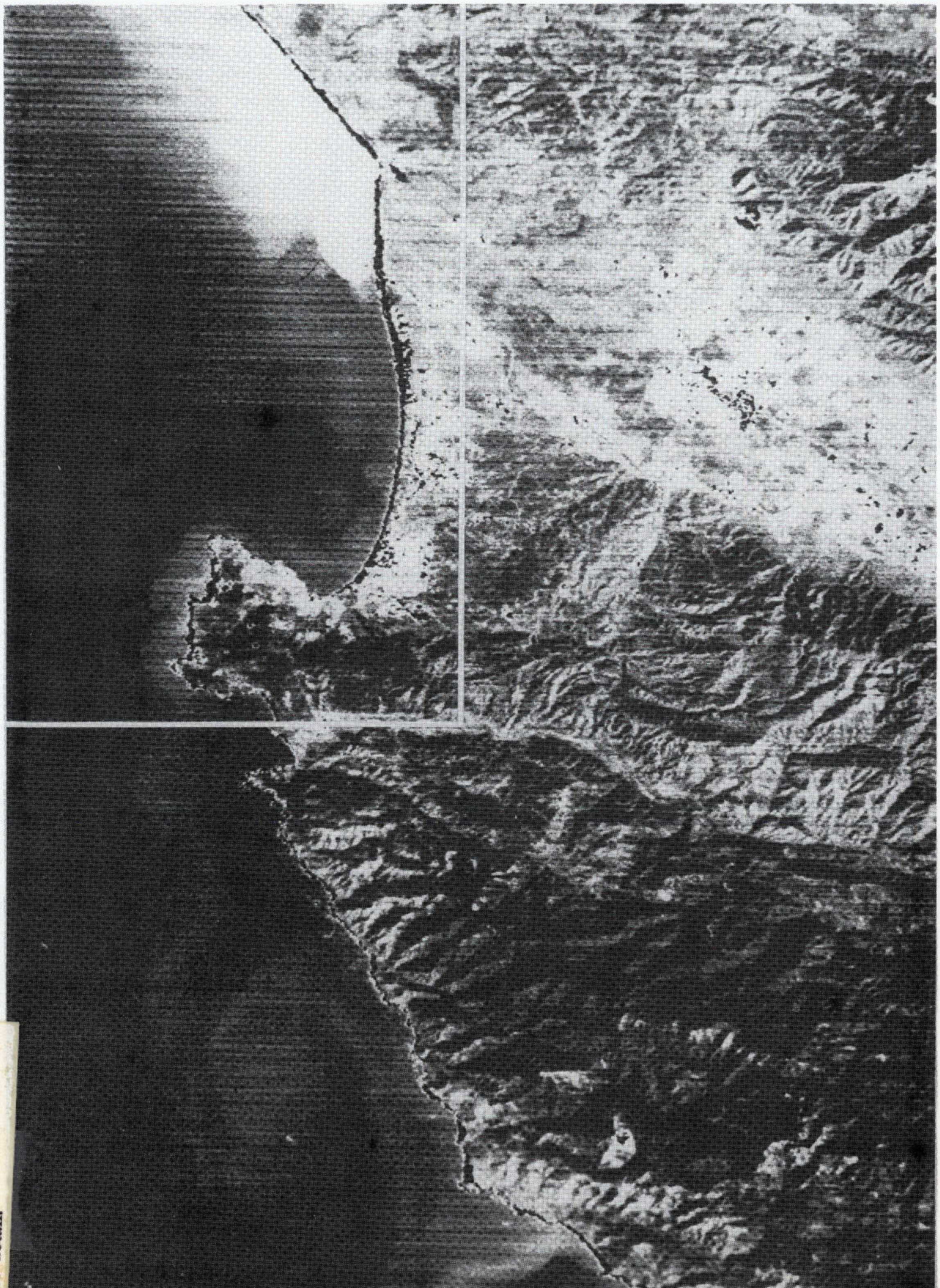


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Figure 39. FSS Enhancement of Monterey Bay
Area of contour map Figures 2 and 40 shown - Scene 1183-18182-4. January 22, 1973.

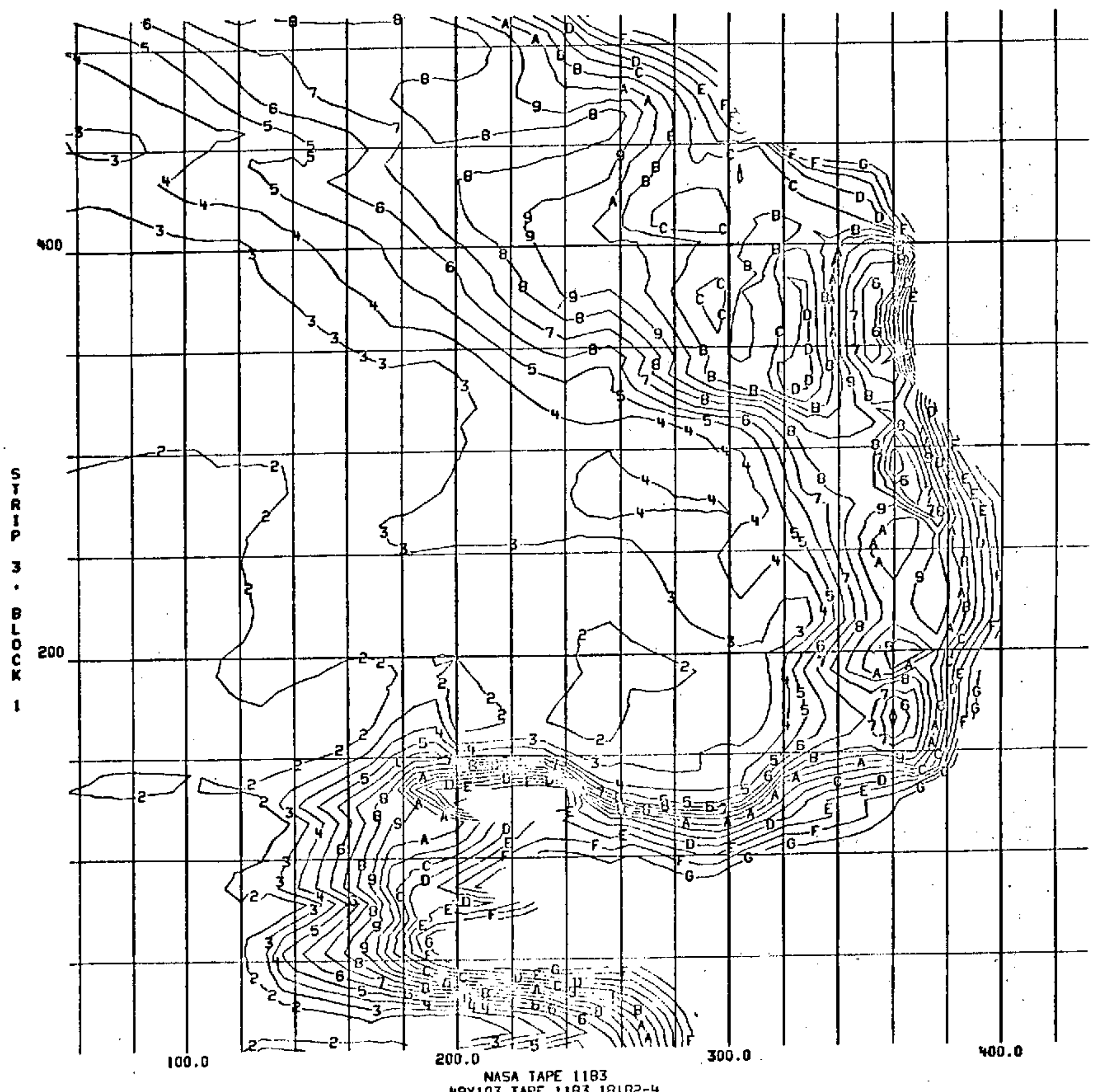

Figure 40. Monterey Bay Contour Map

See Figure 2 for detailed explanation

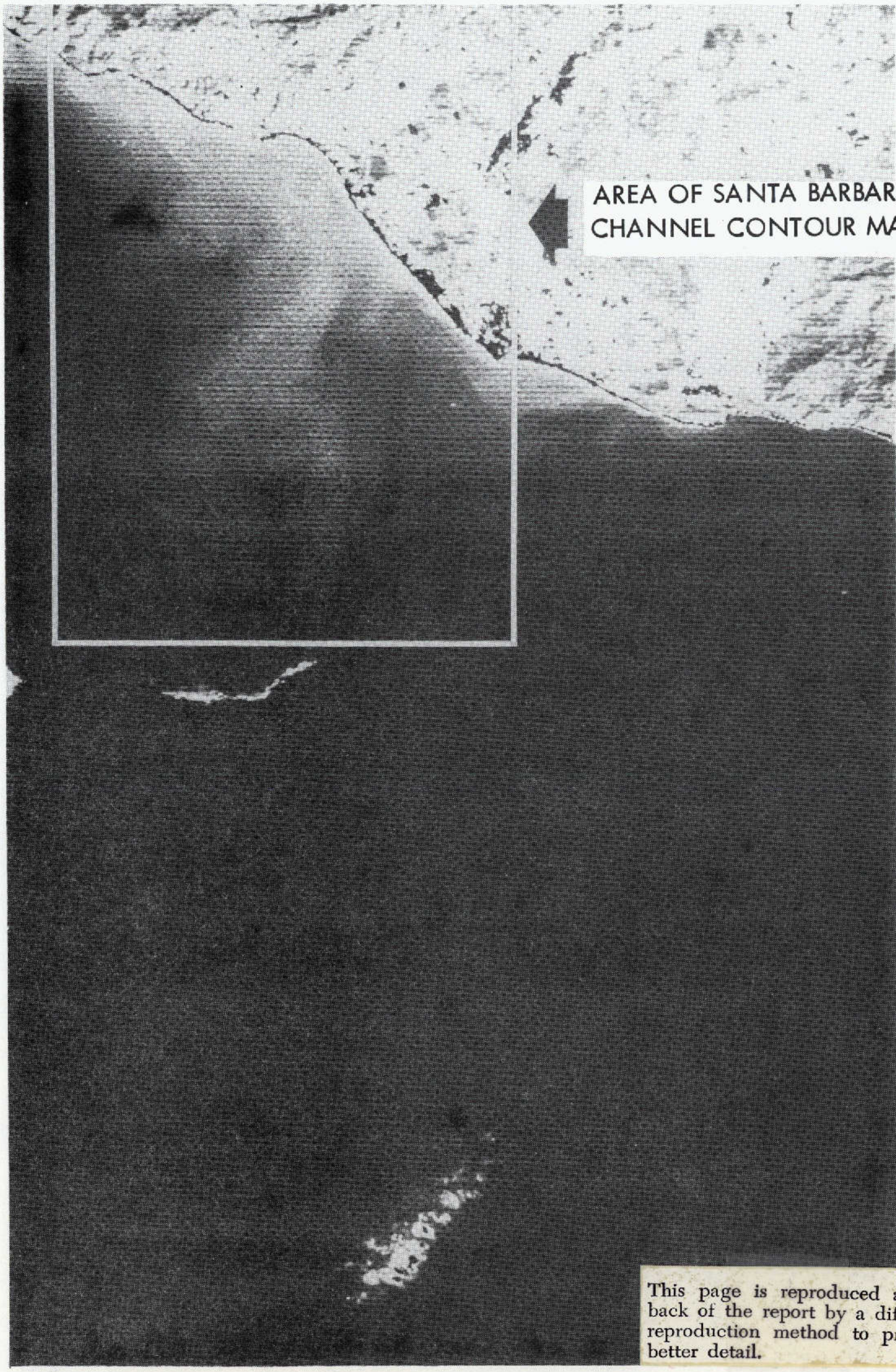

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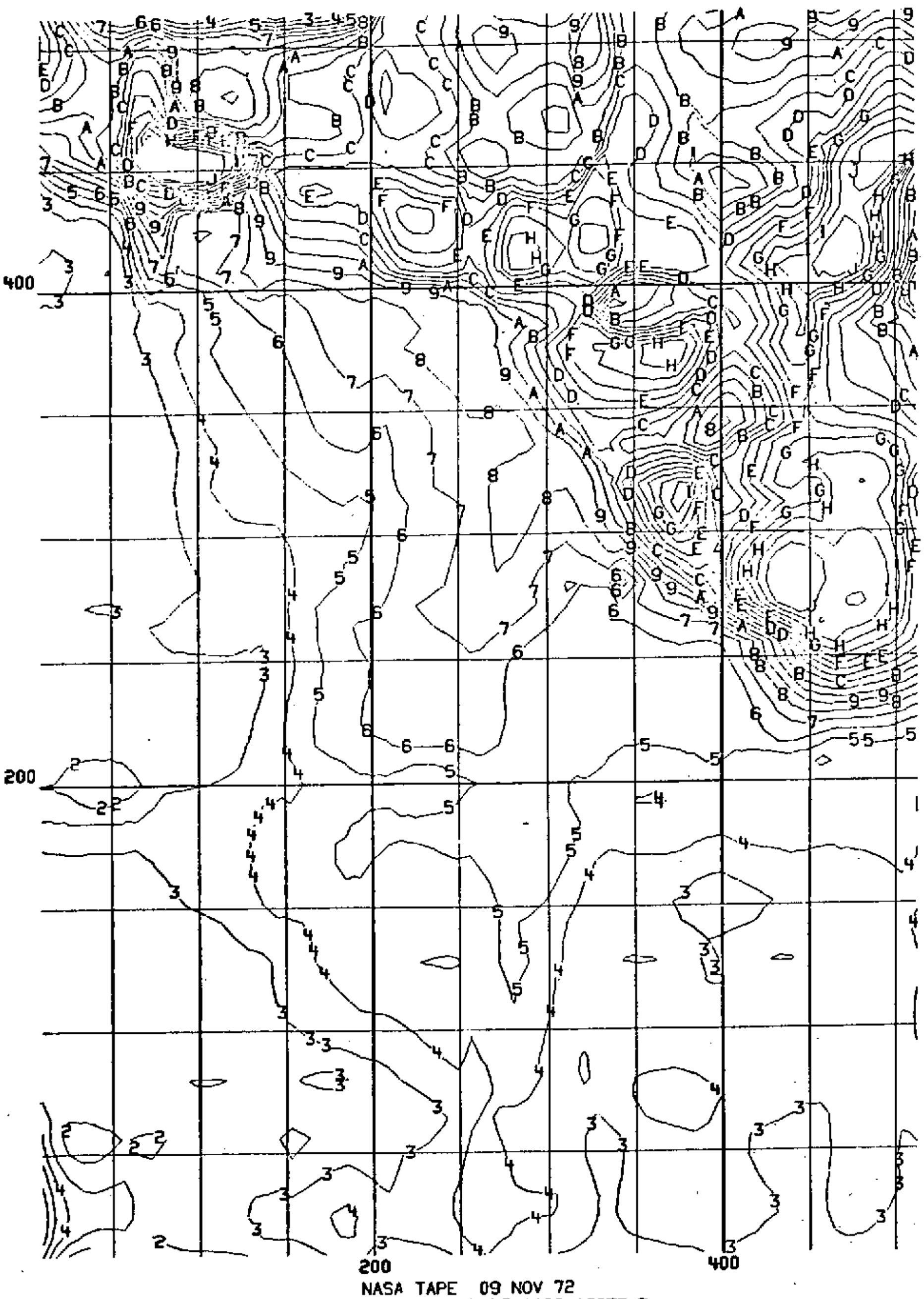
Figure 41. FSS Enhancement, Scene 1109-18073-4, November 9, 1972



1	14.000000
2	15.000000
3	16.000000
4	17.000000
5	18.000000
6	19.000000
7	20.000000
8	21.000000
9	22.000000
A	23.000000
B	24.000000
C	25.000000
D	26.000000
E	27.000000
F	28.000000
G	29.000000
H	30.000000
I	31.000000
J	32.000000

Figure 42. Contour Map of Santa Barbara Channel

See Figure 2 for detailed explanation.

AREA OF
HALF MOON BAY
CONTOUR MAP

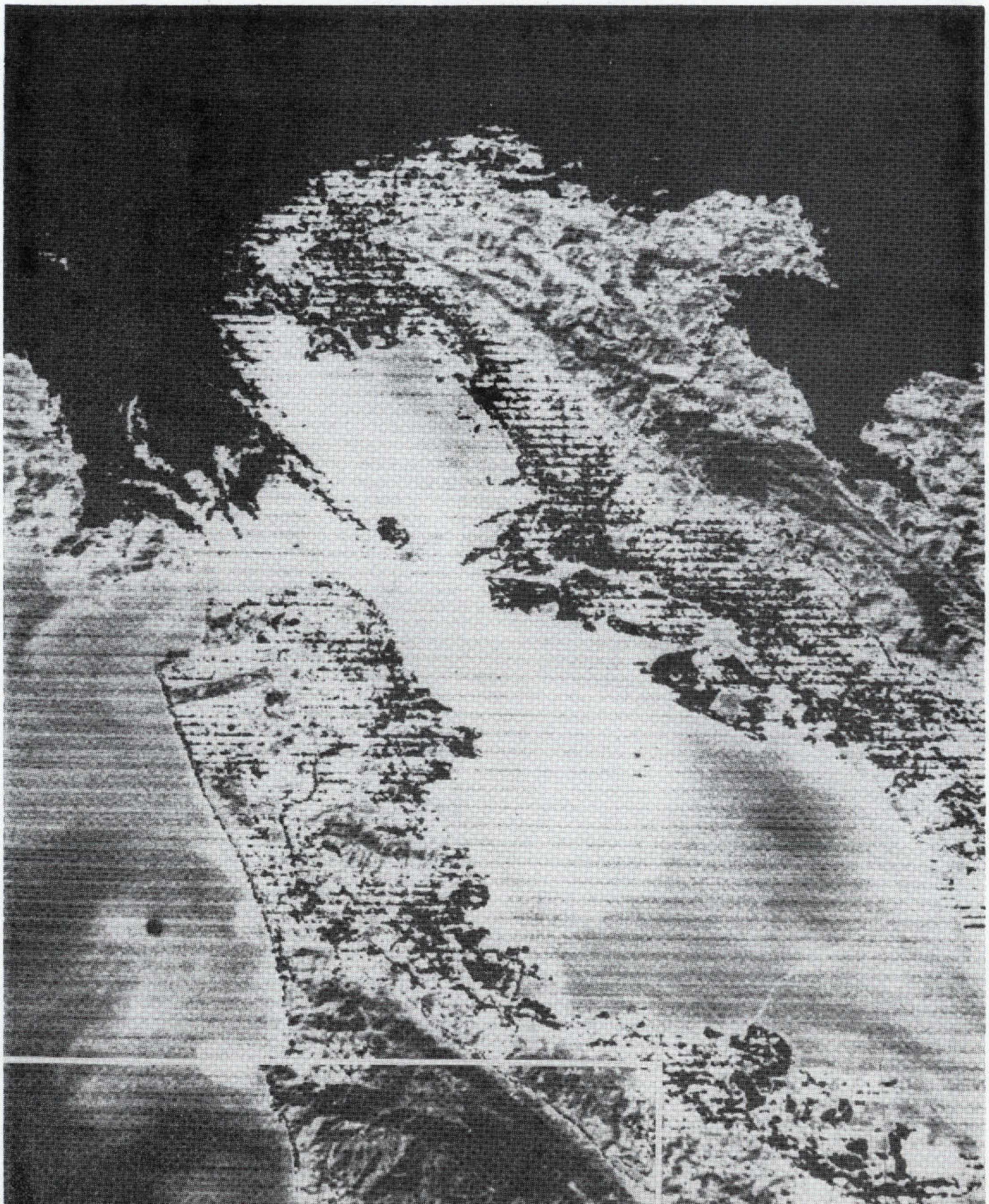


Figure 43. FSS Enhancement - San Francisco Coastal Area
Location of Figure 44 contour map shown.

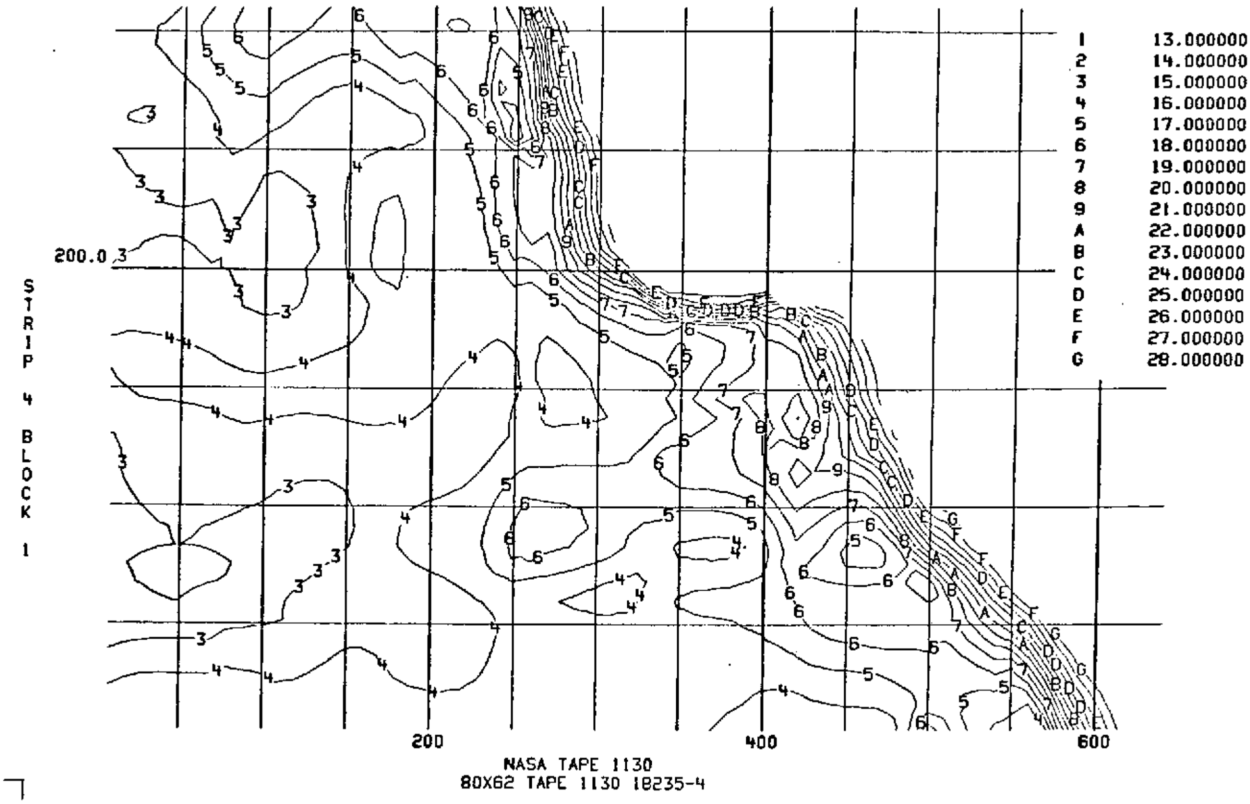


Figure 44. Contour Map - San Francisco Coastal Area.

See Figure 2 for detailed explanation.

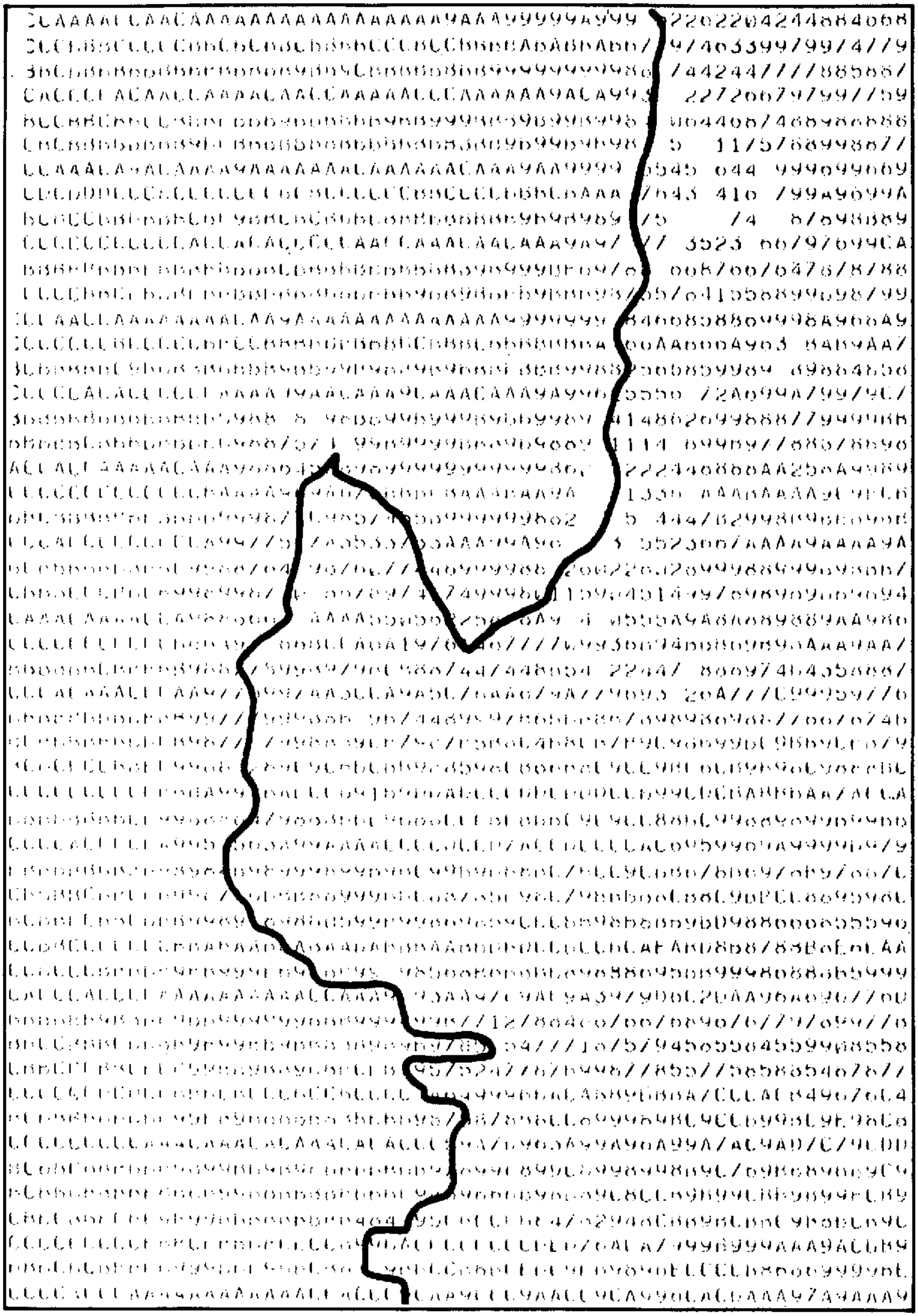


Figure 45. Digital Dump of Monterey Bay Contour Map
SCENE 1183-18182-4

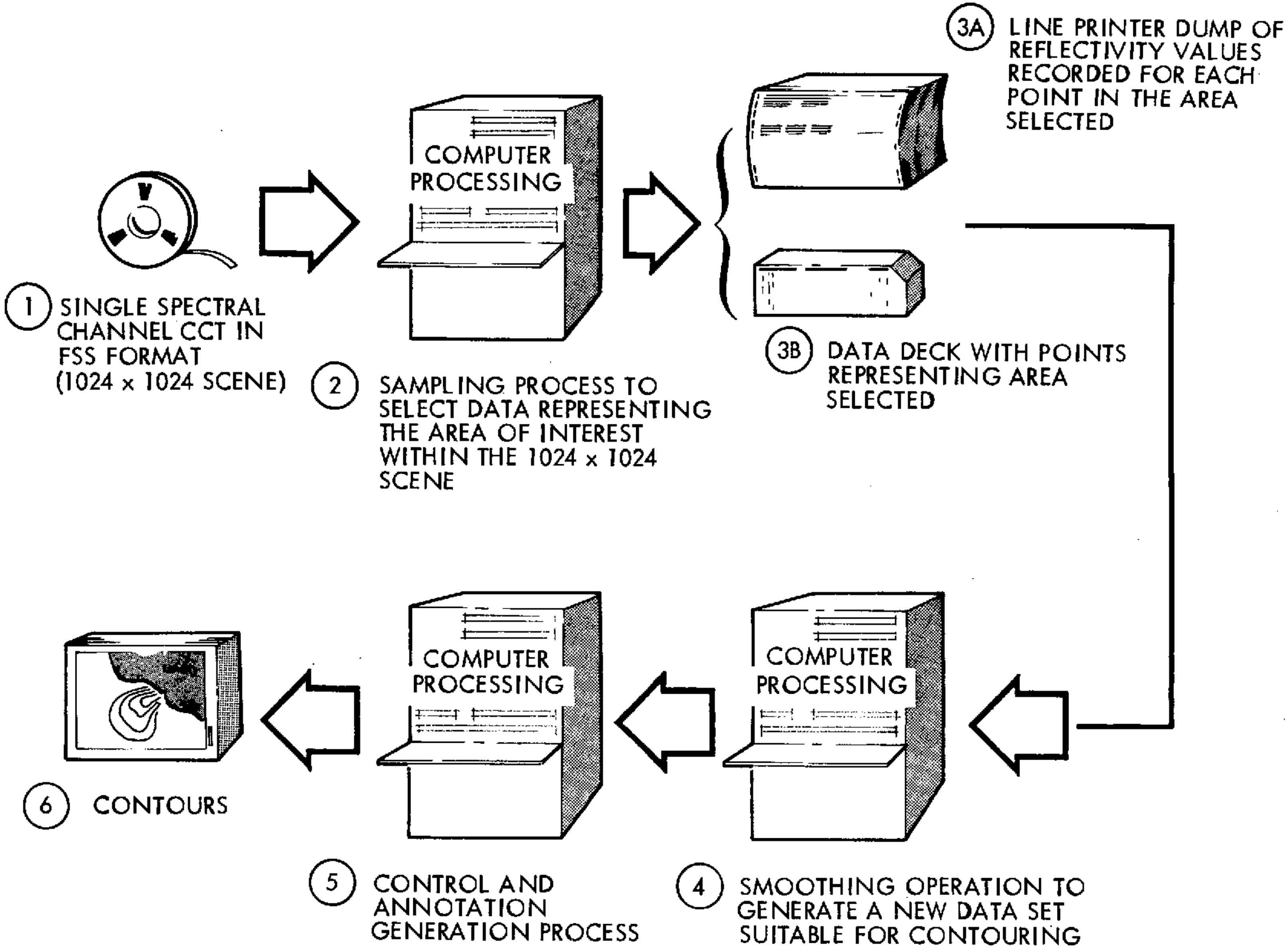

3A LINE PRINTER DUMP OF REFLECTIVITY VALUES RECORDED FOR EACH POINT IN THE AREA SELECTED
COMPUTER PROCESSING
1 SINGLE SPECTRAL CHANNEL CCT IN FSS FORMAT (1024 x 1024 SCENE)
2 SAMPLING PROCESS TO SELECT DATA REPRESENTING THE AREA OF INTEREST WITHIN THE 1024 x 1024 SCENE
3B DATA DECK WITH POINTS REPRESENTING AREA SELECTED
COMPUTER PROCESSING
COMPUTER PROCESSING
6 CONTOURS
5 CONTROL AND ANNOTATION GENERATION PROCESS
4 SMOOTHING OPERATION TO GENERATE A NEW DATA SET SUITABLE FOR CONTOURING

Figure 46

2.7 MICRODENSITOMETER PLOTS

Processing of ERTS data utilizing a microdensitometer results in isodensity contours or line graphs which can be analyzed and correlated with the results of other photo-interpretation processes. The plots in this section were made on a Tech Ops - Joyce Loebl scanning microdensitometer. This system records a total of 64 levels of gray. In the scanning microdensitometer mode, the quantified density values read along a single scan line and are plotted as a line trace of density versus distance.

At the present time these densitometer traces are being used to determine relative changes in density on the ERTS imagery. This information is related to relative changes in reflectance. The significance of the reflectance changes as related to volumetric suspended sediment content is described in Section 2.4. The following Figures (47-51) include examples of ERTS imagery and the accompanying microdensitometer plots.

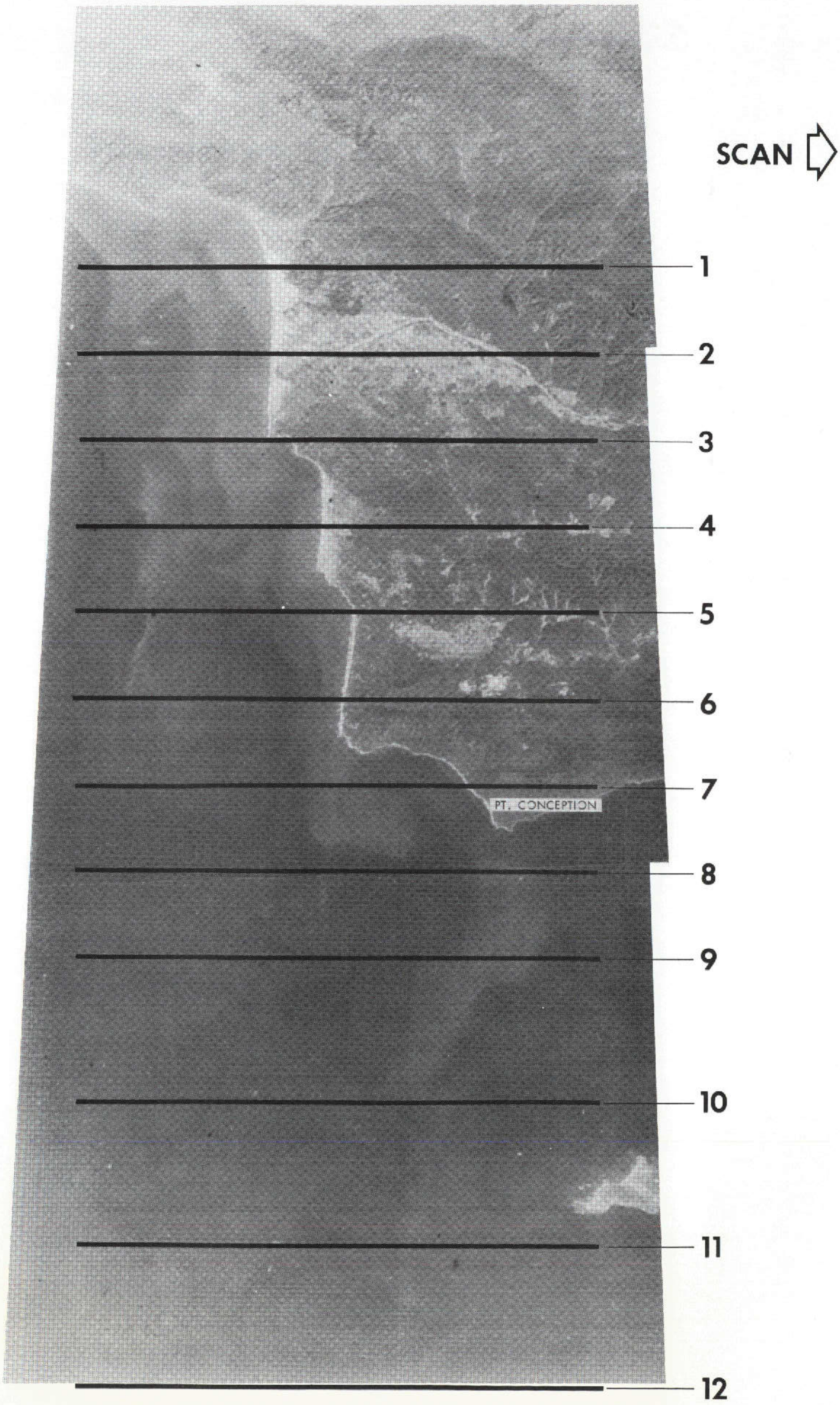
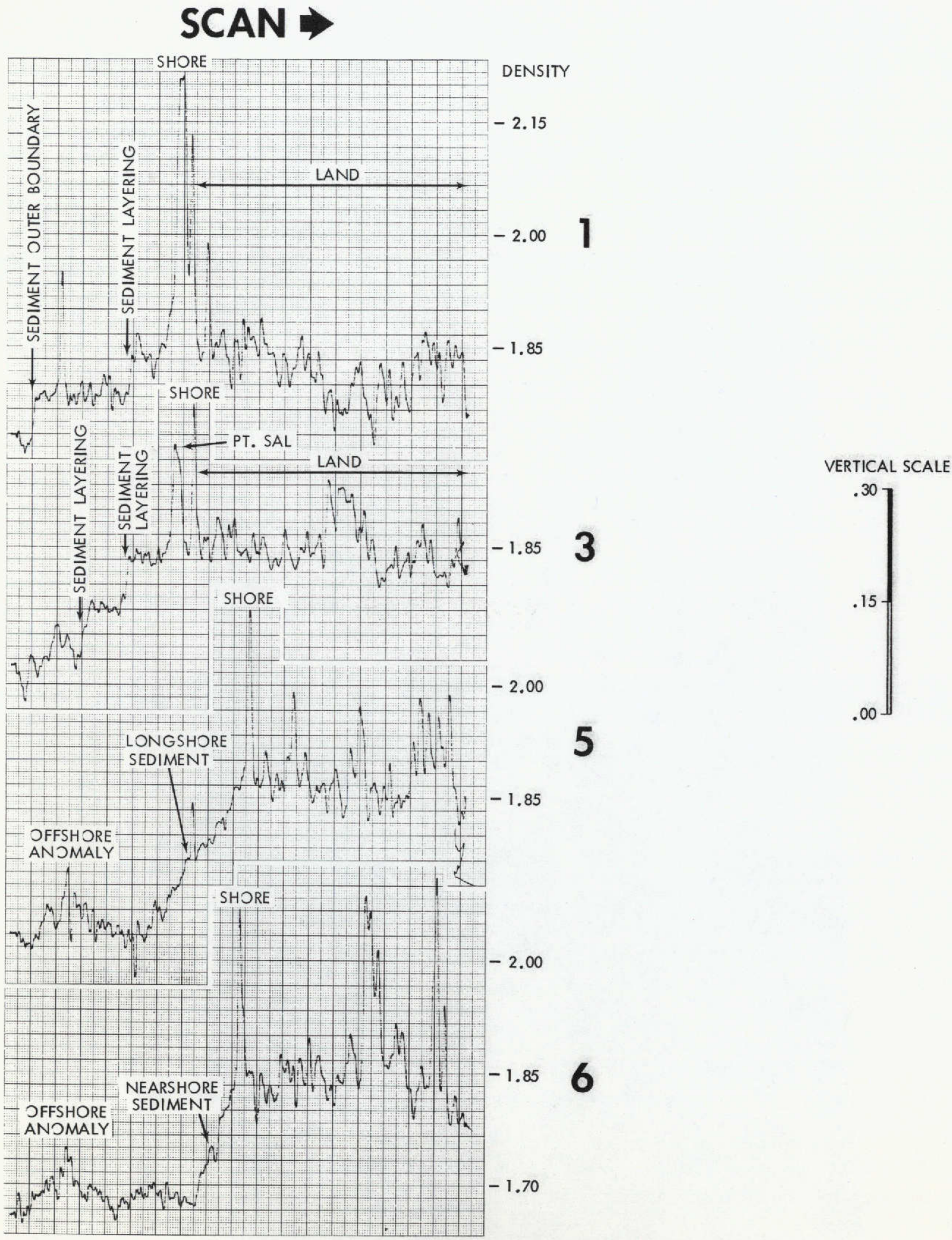


Figure 47. Pt. Conception Area Mosaic

The location of the scan lines represented in Figures 48 and 49 are shown in this mosaic of two ERTS frames 1235-18073-4, and 1235-18075-4. Details of the film density vs. suspended sediment distribution is possibly by comparing the microdensity photo to this mosaic. The imagery was collected March 15, 1973.



Figures 48 and 49. Microdensity Plots – Pt. Conception

The parallel microdensity plots of this scene show the details and extent of the nearshore and offshore suspended sediments in the Pt. Conception, California area (see Figure 47). This scene, 1235-18075-4, was collected March 15, 1973. The microdensity scan was made from original NASA supplied negative transparencies.

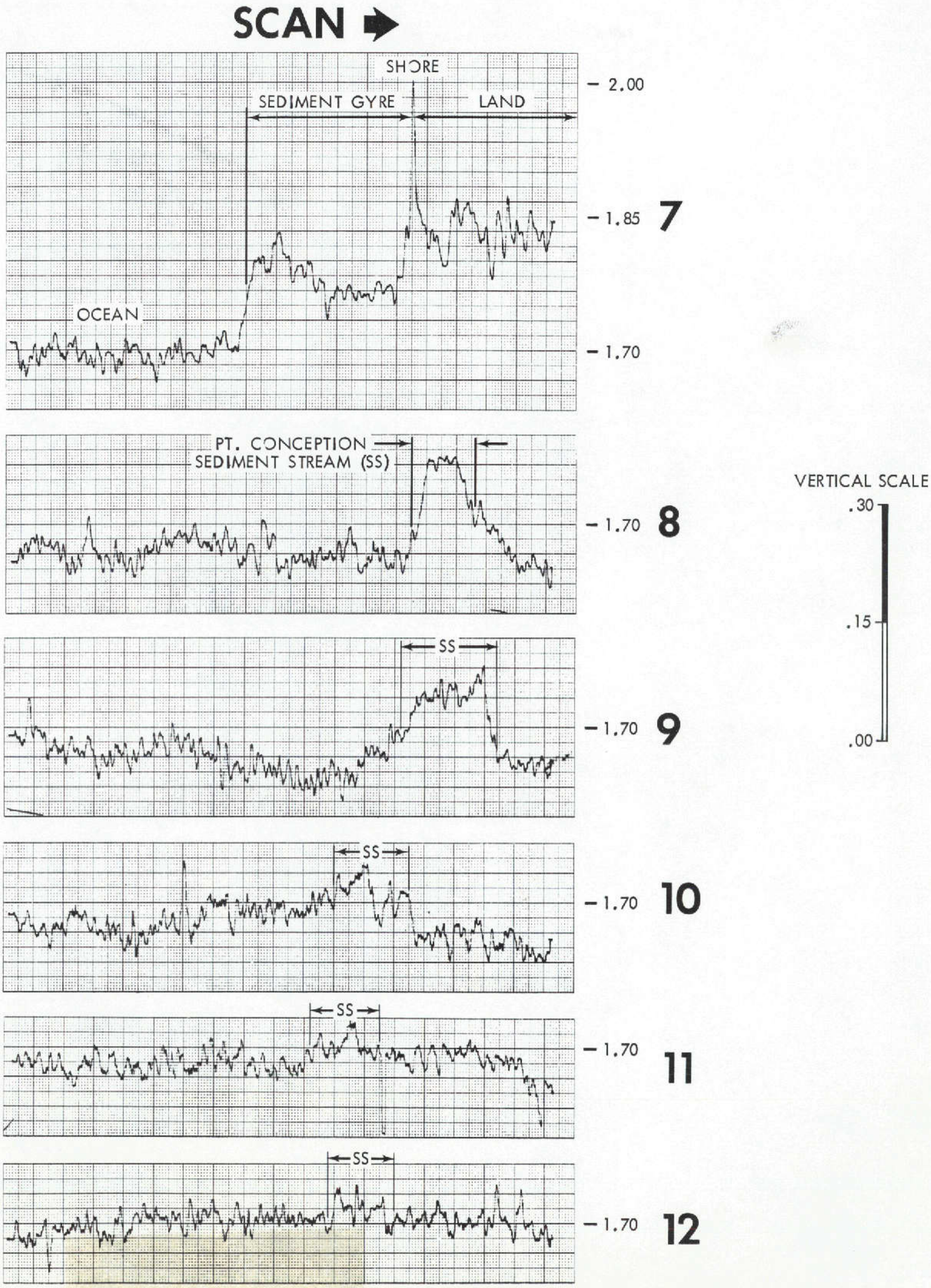


Figure 49. Pt. Conception – Microdensity Plot (Refer to Figure 47)

Figure 50. San Francisco Area - 1255-18183-4

Reference scene for microdensity plot shown on Figure 51. Details of the counterclockwise gyre in the Gulf of the Farallones is illustrated.

This page is reproduced at the back of the report by a different reproduction method to provide better detail.

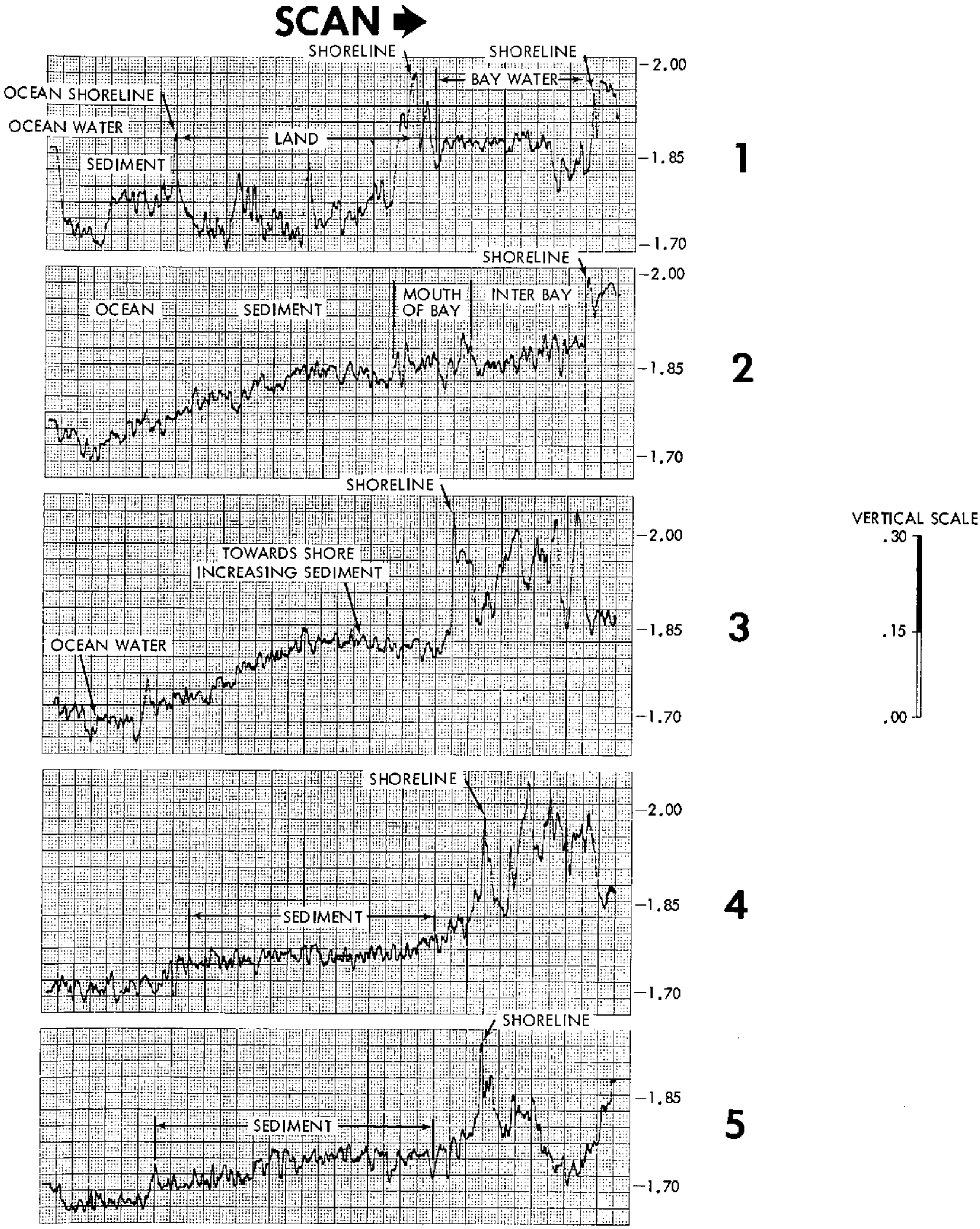


Figure 51. San Francisco Area - Microdensity Plot

3.0 PROGRAMS FOR NEXT REPORTING PERIOD

The next reporting period, October 1973 through February 1974, will be spent completing aircraft flights and data analysis. At least two aircraft data flights will be flown at the test sites. Work will continue on applying ERTS information to operational problems of the U. S. Army Corps of Engineers. Processing and interpretation of ERTS, aircraft and sea truth will be completed and the final report will be prepared.

4.0 CONCLUSIONS

Distinct seasonal patterns for sediment transport as a function of ocean current systems and coastal morphology have been identified. This information is being utilized in coastal engineering and construction projects (i.e., Mad River mouth, Channel Island Harbor).

Large scale sediment plumes from intermittent streams and rivers extend offshore to heretofore unanticipated ranges as shown on the ERTS imagery. Such a plume from the Ventura - Santa Maria Rivers area, which possibly contained agricultural contaminants, was traced to the Anacapa Island area. These contaminants represent a possible source of health deterioration in various Island animals which feed on marine organisms living in the area of the plume.

Tentative calibrations of ERTS spectral brightness against sediment load have been made using aircraft and shipboard measurements.

Although nearshore sediment distributions are highly transitory, large-scale sediment plumes are observed to be relatively stable (as seen on up to two ERTS cycles). This was found off Monterey Bay and Pt. Conception.

Flying Spot Scanner (FSS) enhancement of NASA computer compatible tapes resulted in details of subtle and often invisible (to the eye) nearshore features. The FSS contrast enhancement technique yielded the optimum results.

Computer generated contouring of radiance levels resulted in maps that can be used in determining surface and nearsurface suspended sediment distribution.

5.0 RECOMMENDATIONS

None.

6.0 REFERENCES

CCOFI, 1958, California Cooperative Oceanic Fisheries Investigations: Progress Report, 57 p.

Drake, David Edward, 1972, Distribution and Transport of Suspended Matters, Santa Barbara Channel, California, unpubl. Ph.D. dissertation, University of Southern California, Los Angeles, 357 p.

Drake, David E. and Donn S. Gorsline, 1973, Distribution and Transport of Suspended Particulate Matter in Hueneme, Redondo, Newport and La Jolla Submarine Canyons, California: Contribution #316, Dept. of Geological Sciences, University of Southern California, Los Angeles.

Ecker, Richard, 1973, Personal communication on study of Mad River mouth and adjacent beaches: U. S. Army Engineering District, San Francisco, California.

Ghovanlou, A. H., G. D. Hickman, and J. E. Hogg, 1973, Laser Transmission Studies of East Coast Waters: Tech. Rpt. #2, Sparcom Inc., 49 p.

Hodder, D. T., 1973, Coastal Bathymetric Plotting: Space Division, Rockwell International, SD 73-SA-0131, 53 p.

Hodder, D. T. and M. C. Kolipinski, 1973, Airborne and Satellite Remote Sensing of Anacapa Island for Hydrology and Aquatic Biology: 13th International Technical Scientific Meeting on Space, Rome, Italy, 8 p.

Ingle, Jr., James C., 1966, The Movement of Beach Sand: Elsevier Pub. Co., 221 p.

Inman, Douglas L. and Borchard M. Brush, 1973, The Coastal Challenge: Science, v. 181.

Jones, James H., 1971, General Circulation and Water Characteristics in the Southern California Bight: Southern California Coastal Water Research Project, 37 p.

Kolpack, R. L. (editor), 1971, Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill, Vol. II, Physical, Chemical and Geological Studies, Allen Hancock Foundation, University of Southern California, Los Angeles, 477 p.

Natland, M. L. and Kuenen, P. H., 1951, Sedimentary History of Ventura Basin, California, and the Actions of Turbidity Currents, p. 66-107 in Hough, J. L., Ed., Turbidity Currents and the Transportation of Course Sediments to Deep Water: Soc. Econ. Paleontologists and Mineralogists Spec., Pub. No. 2.

Scruton, P. C. and D. G. Moore, 1953, Distribution of Surface Turbidity off Mississippi Delta: Am. Assoc. Petroleum Geologists Bull., V. 37, p. 1067-1074.

Shepard, F. P. and K. O. Emery, 1941, Submarine Topography off the California Coast, Canyons and Tectonic Interpretation: Geol. Soc. America Spec. Paper 31, 171 p.

Specht, M. R., D. Needler, and N. L. Fritz, 1973, New Color Film for Water Photography Penetration: Photogrammetric Engineering, p. 359-369.

__________, 1971, Dredge Disposal Study for San Francisco Bay and Estuary: U. S. Army Engineering District, San Francisco, California, 32 p.

__________, 1973, The Ecology of the Southern California Bight, Implications for Water Quality Management: Southern California Coastal Water Research Project, 531 p.

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GSFC D 324

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	Suspens-ates	Clouds	Dark	
				Explanation Band R - All RBV bands M - All MSS bands Format M - 70 MM neg. S - 70 MM pos. 9P - 9 track tape precision 9B - 9 track tape bulk
1002-18134 R 4,5,7 M 9P			X	Monterey
1002-18140 R 4,5,7 M			X	Monterey Bay
1003-18175-5 Color neg.				
1004-18224 R M		X	X	Pt. Reyes
1004-18230 R M			X	San Francisco
1005-18271 R M			X	
1005-18274 R M			X	
1006-18331 R M			X	

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1006-18333	R M			X	
1006-20080	M M				Tuktoyaktuk
1018-18003	6, 7 M			X	
1018-18010	M M			X	
1018-18012	4,5 M			X	
1019-18062	M M			X	
1019-18064	M M		X	X	
1020-18115	M M			X	
1020-18121	M M		X	X	Morro Bay
1020-18124	M M			X	
1021-18172	4,5,6,7 M			X	
1021-18174	M M			X	Monterey
1022-18223	M M			X	
1022-18223	M M			X	

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		Suspensates	Clouds	Dark	
1022-18230	M M			X	Pt. Arena
1034-17500	4, 5 M			X	Salton Sea
1034-17502	6, 7 M			X	
1035-17554	M M			X	
1036-18010	M M			X	Los Angeles
1036-18012	M M			X	
1037-18064	M M			X	Santa Barbara
1038-18120	M M		X	X	
1039-18172	M M		X		San Francisco
1041-18274	M M			X	
1041-18280	M M			X	
1041-18283	M M		X		
1052-17495	M M			X	Salton Sea

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		Suspens-ates	Clouds	Dark	
1053-17554	M N		X		Long Beach, San Diego
1053-17560	M M			X	Tijuana
1054-18010	M M		X	X	Pt. Dume
1055-18064	5,6,7 M		X		Santa Barbara, Channel Island
1055-18071	4,5,6 M		X	X	
1056-18120	4,5,6,7 M			X	Morro Bay
1056-18123	M M			X	Pt. Conception
1057-18170	M M		X	X	
1057-18172	M M		X	X	
1057-18175	M M			X	Carmel, Pt. Sur
1058-18224	M M		X		Pt. Arena, Russian River
1058-18230	M M, S		X		San Francisco Bolinas Bay
1059-18273	M M				Cresecent City

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		Suspensates	Clouds	Dark	
1059-18280	M M, S				Humboldt Bay Eel River
1059-18282	M M		X		Pt. Arena
1060-18332	M M			X	
1070-17495	M M				Salton Sea
1071-17554	M M		X		Long Beach San Diego Bay
1072-18010	M M		X		
1072-18012	M M				Los Angeles
1073-18064	M M 9P				Channel Island Santa Barbara
1074-18121	M M 9P				Morro Bay
1074-18123	M M				Pt. Conception San Luis Obispo
1075-18173	M M, S, 9P(dup)				San Francisco Monterey
1076-18225	M M		X	X	San Francisco
1076-18231	M M		X		Pt. Ano Nuevo
1077-18274	M M		X		

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PRODUCT ID (INCLUDE BAND AND PRODUCT)		FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
		Suspens-ates	Clouds	Dark	
1077-18281	M M		X		Humboldt Bay
1078-18333	4,6,7 M		X		
1078-18335	5,6,7 M		X		
1089-17563	M M		X		
1090-18012	M M, S, 9P	X			Santa Barbara Anacapa Island
1090-18015	M M, S, 9P				Los Angeles Catalina Island
1091-18071	M M, 9P				
1093-18173	 M, 9P	X			N. San Francisco
1094-18233	M M				San Francisco Bolinas
1095-18280	M M, 9P		X		Crescent City
1095-18283	M M, 9P(dup) 9B	X			Humboldt Bay
1096-18335	M M, 9B(dup)	X			Crescent City Klamath River
1096-18341	M M	X			Humboldt Bay

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PRODUCT ID (INCLUDE BAND AND PRODUCT)		FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
		Suspensates	Clouds	Dark	
1106-17504	M S, 9P(Dup)				Salton Sea
1107-17562	M S, 9P				San Diego
1107-17564	M S				Baja
1108-18014	M M, S, 9P	X			Santa Barbara Channel Islands
1108-18020	M M, S, 9P				Santa Catalina Santa Barbara dye drop St. Nicholas
1109-18070	M M, S, 9P				Bakersfield
1109-18073	M M, S, 9P(Dup) 9B	X			Santa Barbara
1111-18181	M S, 9P		X		Monterey Bay
1112-18233	M M, S, 9P 9B(Dup)	X			Russian River Pt. Reyes
1112-18235	M S		X		
1113-18291	M S		X		
1114-18340	M S, 9P				Klamath River

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		Suspensates	Clouds	Dark	
1124-17504	M S, 9P				Salton Sea
1125-17563	M M, S, 9P(Dup)				Long Beach to Mexican Border
1125-17565	M S				Baja
1126-18015	M M, S, 9P				Los Angeles
1127-18071	M S		X		
1127-18073	M M, S, 9B, 9P				Santa Barbara
1127-18080	M S				San Nicholas Island
1129-18181	M M, S, 9P	X			Monterey Bay
1129-18183	M M, S, 9P				Monterey
1129-18190	M M, S				Monterey
1130-18233	M 4,5 M, S, 9P, 6, 7 S				Russian River Pt. Reyes
1130-18235	M 4, 5 M, S- 9P, 9B, 6, 7 S				San Francisco Pt. Reyes

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PRODUCT ID (INCLUDE BAND AND PRODUCT)		FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
		Suspensates	Clouds	Dark	
1131-18282	M S, 9P		X		
1131-18285	M S, 9P		X		
1131-18291	M S		X		
1132-18341	M S		X		
1132-18343	M S		X		
1142-17504	M S, 9P				Salton Sea
1143-17563	M S				Long Beach Catalina Island
1143-17565	M S		X		
1144-18015	M 4,5 M, S, 9P, 6, 7, S				Santa Barbara Anacapa
1144-18021	M S		Haze		Newport Catalina Island
1145-18073	M S		Clouds Haze		Santa Barbara Channel
1145-18080	M S		Clouds		San Nicholas Island
1146-18125	M S		X		

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		Suspens-ates	Clouds	Dark	
1146-18131	M S		Haze		
1148-18233	M S		Clouds		
1148-18235	M S		X		
1160-17503	M S, 9P				Salton Sea
1161-17561	M S	X			Long Beach to Mexican Border
1161-17564	M S				Pt. Conception
1162-18013	M S, 9P(Dup) 9B(Dup)				Santa Barbara to Long Beach
1162-18020	M S				Palos Verde to Oceanside
1163-18065	4,5,6,7 M S				San Joaquin Valley
1163-18072	M S, 9P	X			San Luis Obispo to Pt. Conception
1163-18074	M S				San Nicholas Island
1164-18123	M S, 9P(Dup)	X			Morro Bay
1164-18130	M, 4,5,6,7 S				Pt. Conception

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PRODUCT ID (INCLUDE BAND AND PRODUCT)		FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
		Suspensates	Clouds	Dark	
1165-18175	M M, S, 4, 5, 6, 7, S 9P, 9B(Dup)				San Francisco
1165-18182	M S, 9P(Dup)				Monterey
1165-18184	M S				
1166-18231	M S				Bolinas Bay Pt. Arena
1166-18234	M S		X		Pt. Reyes
1167-18280	M 4,5 M, S, (P, 6, 7, S	X			Patricks Point to Crescent City
1167-18283	M M, S, 4,5, 6, 7, S, 9P	X			Humboldt Bay
1167-18285	M S, 9P	X			Pt. Arena
1168-18335	M, 4 S, 9P		X		
1171-18285	M S, 9P				
1178-17504	M, 5,6,7 S, 9P				Baja
1179-17561	M S, 9P	X			Newport to Mexican Border

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1179-17563	M S	X			Baja
1180-18013	M S, 9P	X			Santa Barbara to Santa Monica Bay
1180-18015	M S	X			Newport
1180-18015	M S				
1181-18071	M S		Haze		Pt. Conception
1181-18074	M S		X		Channel Island
1182-18123	M S				
1182-18130	M S				
1183-18175	4,6,7 M, 9B (Dup)	X			San Francisco to Monterey
1183-18182	M, 5,6,7 M, 9B (Dup)				Monterey to Lopez Point
1184-18231	M M		X		
1184-18234	M M				San Francisco Bay Russian River
1186-18335	M M		X		

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1186-18342	M M		X		Humboldt Bay
1196-17504	M M				Salton Sea
1197-17563	M M		X		
1197-17565	M M		X		
1198-18015	M M				
1198-18021	M M		X		
1199-18073	M M		X		
1199-18080	M M		X		
1200-18125	M M				Pt. Sur to Morro Bay
1200-18132	M M	X			Pt. Conception
1202-18233	M M		X		
1203-18283	M M		X		
1203-18285	M M		X		

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PRODUCT ID (INCLUDE BAND AND PRODUCT)		FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
		Suspens-ates	Clouds	Dark	
1203-18292	M M		X		
1204-18344	M M		X		
1215-17564	M M		X		Palos Verdes to San Diego
1215-17570	M M				Baja
1217-18074	4,5,7 M	X			Santa Barbara
1217-18081	M M		X		Santa Rosa Island San Nicolas Island
1218-18133	M M		X		Santa Rosa Island San Nicolas Island
1218-18133	M M		X		
1222-18342	M M				Humboldt Bay
1222-18345	M M	X			Humboldt Bay
1232-17510	M M		X		Salton Sea
L232-17513	M M		X		Baja
1234-18021	M M	X			Santa Barbara

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO ERTS USER SERVICES
CODE 563
BLDG 23 ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-5406

GSFC 37-2 (7/72)

ERTS IMAGE DESCRIPTOR FORM

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PRODUCT ID (INCLUDE BAND AND PRODUCT)		FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
		Suspensates	Clouds	Dark	
1234-18023	M M	X			Santa Cruz to San Clemente Island Wakes
1235-18073	M M				San Joaquin
1235-18075	M M	X			Santa Barbara
1235-18082	M M	X			San Nicolas Island S. Santa Rosa Island
1236-18131	M M		X		Monterey
1236-18134	M M		X		Pt. Conception
1237-18181	M M		X		San Francisco
1237-18183	M M		X		Monterey Bay
1237-18190	M M		X		Monterey Bay
1237-18192	M M		X		Ocean
1238-18233	M M				Sacramento Valley
1238-18235	M M	X			Pt. Reyes Pt. Mendozina
1238-18242	M M	X			Pt. Reyes San Francisco

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PRODUCT ID (INCLUDE BAND AND PRODUCT)		FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
		Suspens-ates	Clouds	Dark	
1240-18343	M		X		Humboldt Bay
1240-18345	M M		X		
1251-17565	M M		X		Newport to San Diego
1252-18021	M M				Santa Barbara to Palos Verdes
1252-18023	M M				Santa Cruz to San Clemente
1253-18073	5,6,7 M				San Joaquin Valley
1253-18075	M M		X		Santa Barbara Channel
1253-18082	M M				Santa Rosa Island San Nicolas Island
1254-18131	M M	X			Monterey Bay
1254-18134	M M	X			Pt. Conception
1255-18183	M M	X			San Francisco Monterey
1255-18190	M M				Monterey
1255-18192	M M	X			
1256-18233	M M				Sacramento Valley

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PRODUCT ID (INCLUDE BAND AND PRODUCT)		FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
		Suspensates	Clouds	Dark	
1256-18235	M M		X		Ft. Bragg
1256-18242	5,6,7 M		X		San Francisco Bay
1257-18285	M M				Humboldt Bay
1257-18291	M M				Pt. Arena
1257-18294	M M				Pt. Arena
1258-18343	M M	X			Crescent City Humboldt Bay
1258-18345	M M				
1268-17510	M M		X		Salton Sea
1268-17513	M M				Baja
1269-17565	M M		X		Palos Verdes to Mexico border
1269-17571	M M				Baja
1270-18021	M M				Santa Barbara
1270-18023	M M				Palos Verdes Islands

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PRODUCT ID (INCLUDE BAND AND PRODUCT)		FREQUENTLY USED DESCRIPTORS* Suspensates	Clouds	Dark	DESCRIPTORS
1271-18072	M M				San Joaquin Valley
1271-18075	M M	X			Santa Barbara Channel
1271-18081	M M	X			Channel Islands
1273-18183	M M	X			San Francisco Monterey
1273-18185	4,5 M	X			Monterey
1273-18192	M M	X			Ocean
1274-18232	M M				Sacramento Valley
1274-18235	M M				Ft. Bragg to Bodega Head
1274-18241	M M	X			San Francisco
1275-18284	M M	X			Crescent City
1275-18290	M M				Patricks Point
1276-18342	M M		Fog		Humboldt Bay
1286-17505	M M		Clouds		Salton Sea

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PRODUCT ID (INCLUDE BAND AND PRODUCT)		FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
		Suspensates	Clouds	Dark	
1287-17564	M M		X		Santa Catalina
1290-18130	4,5,7 M	X			Monterey
1290-18133	4,5,7 M	X			Pt. Conception
1291-18182	M M	X			Monterey Bay
1291-18184	M M	X			Monterey
1291-18191	4,5,6 M				Open Ocean South of Pt. Sur
1292-18231	M M				
1292-18234	M M				
1292-18240	5,7 M				
1293-18283	M M				
1293-18290	M M				
1311-18282	4,5,6,7 M				Crescent City
1326-18130	4 M				

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PRODUCT ID (INCLUDE BAND AND PRODUCT)		FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
		Suspensates	Clouds	Dark	
1330-18342	5 M				
1340-17475	4,5,6,7 S				
1340-17502	4,5,6,7 M				Salton Sea San Diego
1340-17504	4,5,6,7 M				Baja
1347-18280	4,5,6 M				
1347-18282	4,5,6,7 M				
1347-18285	4,6 M				
1362-18121	4,5,6,7 M				
1363-18171	4,5,7 M				
1363-18173	4,5,6,7 M				
1363-18180	4,5,6,7 M				

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8.0 INDEX

9.0 SIGNIFICANT RESULTS

California Coast Nearshore Processes Study Contract S-70257-AG

Douglas M. Pirie DE324 Principal Investigator
David D. Steller Co-Investigator

Progress Report Type II, No. 2 March 1 - August 31, 1973
Report Category SH

Large scale sediment plumes from intermittent streams and rivers form detectable seasonal patterns on the ERTS imagery. The ocean current systems, as plotted from three California coast ERTS mosaics, were identified. This data is being utilized in coastal engineering and construction projects (i.e., Mad River mouth, Channel Island Harbor) as seasonal current movement background.

Offshore patterns of sediment in areas such as the Santa Barbara Channel are traceable. These patterns extend offshore to heretofore unanticipated ranges as shown on the ERTS imagery.

Flying Spot Scanner (FSS) enhancements of NASA computer compatible tapes resulted in details of subtle and often invisible (to the eye) nearshore features. The suspended sediments off San Francisco and in Monterey Bay are emphasized in detail. These are areas of extremely changeable offshore sediment transport patterns.

Computer generated contouring of radiance levels resulted in maps that can be used in determining surface and nearsurface suspended sediment distribution.

Tentative calibrations of ERTS spectral brightness against sediment load have been made using aircraft and shipboard measurements.

Information from the combined enhancement and interpretation techniques is applicable to operational coastal engineering programs.